STUDIES ON INDUCED MUTATAION IN GLADIOLUS (*Gladiolus hybrida* L.) THROUGH GAMMA RAYS

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CERTIFICATE – I

This is to certify that the thesis entitled **"Studies on induced mutataion in gladiolus (*Gladiolus hybrida* L.) through gamma rays"** submitted to the Faculty of Agriculture, Assam Agricultural University in partial fulfillment for the degree of **Master of Science (Agriculture)** in **Plant Breeding & Genetics** is a record of research work carried out by **Shephali Priya** under my personal supervision and guidance.

All helps received by her have been duly acknowledged.

No part of this thesis has been reproduced elsewhere for any degree.

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ABSTRACT

Gladiolus (*Gladiolus hybrida* L.) is one of the important bulbous crop, cultivated in various parts of the country. It is an important bulbous crop which occupies important position among cut flowers in domestic as well as international market so, mutation is important for obtaining variety easily. In the present investigation to find out the genetic variability for morphological and quality traits, their association and mutation frequency, effectiveness, efficiency of gamma rays in four genotypes for 13 characters. A factorial randomized block design was conducted in four genotypes which is treated with six doses of gamma rays.

The analysis of variance for factorial randomized block design it was observed that significant variation was there for all characters except no. of leaves per plant among 4 varieties. The character spike length, no. of spike per plant exhibited highest PCV, GCV in M_1V_1 generation. The character plant height, no. of spike exhibited highest PCV, GCV in M_1V_2 generation. Heritability with genetic advance was found to be high in vase life, days to sprouting, spike length, rachis length and no. of floret per spike in M_1V_1 generation. In M_1V_2 generation, heritability high days to sprouting, spike length, vase life, days to spike initiation, breadth of leaf.

The effect of interaction between variety and doses indicated that the better plants was found at 20 Gy and as decreased as the doses were increases 'Red Majesty' is the best performed variety for breadth of leaf, no. of floret per spike, length of floret, breadth of floret, vase life, no. of spike per plant followed by Red Candiman, Pasibica Beauty.

In the correlation studies no. of spike per plant showed a highly significant and positive correlation with the characters plant height, spike length, rachis length, no. of floret per spike, length of floret and vase life. The study of path analysis revealed that the characters no. of floret per spike, breadth of leaf and days to spike initiation had direct positive effect on no. of spike whereas days to sprouting, rachis length, breadth of floret, plant height and vase life showing negative direct effect.

Highest mutation frequency observed in 40Gy, mutagenic effectiveness in 20Gy and efficiency in 50Gy of variety Red majesty.

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LIST OF ABBREVIATIONS

%	:	Percent
@	:	At The Rate Of
°	:	Degree
C.D.	:	Critical difference
LSD	:	Least square difference
C.V.	:	Coefficient of variation
cm	:	Centimetre
et al.	:	*Et Alli* (And Others)
Gy	:	Gray
M_1V_1	:	First Mutation & First Vegetative Generation
M_1V_2	:	First Mutation & Second Vegetative Generation
Fig.	:	Figure
viz.	:	*Videlicet* (As Follows)
PCV	:	Phenotypic Coefficient of Variation
GCV	:	Genotypic Coefficient of Variation
GA	:	Genetic Advance
h^2	:	Heritability
ha	:	Hectare
i.e	:	That is
g	:	Gram
L.	:	Carl Linnaeus
f.sp.	:	Forma specialis
cv	:	Cultivar versus
FRBD	:	Factorial Randomized Block Design
S.Em(±)	:	Standard error of mean
LD_{50}	:	Lethal dose 50%
EMS	:	Ethyl methane sulphonate

CHAPTER I
INTRODUCTION

Flowers are the most beautiful and greatest gift of God. The word ‘flower’ brings in a feeling of a fresh breath. Flower symbolizes all the earthly feelings like love, sacrifice, beauty etc. India is known for its rich biodiversity across the world and is greatly blessed with different of varieties flowers of different colours. From time immemorial, flowers have been an integral part of Indian society. It is mainly cultivated for aesthetic, social and religious purposes. With the increase in urbanization and globalization a number of occasions like valentine’s day, father’s day, mother’s day, friendship day, birthday’s, anniversary etc. become quite popular in India. Due to the influence of western culture “saying it with flower further” increased the demand of flowers to the substantial extent. Furthermore, a significant amount of flowers are used for religious purpose too. The domestic demands for flowers are increasing at an exponential rate. Due to the strong demand of cut flowers and loose flowers at national and international level, floriculture is considered as one of the important commercial trader in Indian agriculture. Govt. of India has identified floriculture as a sunrise industry today. This industry promises a huge potential for the Indian farmers. In 2018, the Indian floriculture market was worth INR 157 Billion and it has been estimated that it will reach INR 472 Billion by 2024. One of the major shares of floriculture industry is occupied by cultivation and trade of cut & loose flowers. Indian floriculture industry has been shifting from traditional flowers to cut flowers due to its growing demand in the international and national markets.

Among the various commercially important cut flowers gladiolus occupies an important position in the market. Gladiolus is basically a commercial flower crop. This crop is known as for its wide range of colours, shapes, keeping quality etc. across the world. Hence, it is also known as the “Queen of bulb”.

Gladiolus (*Gladiolus hybrida* L.) is one of the important bulbous crop, cultivated in various parts of the country. ,

Gladiolus, a member of the family Iridaceae, is one of the most popular ornamental plants grown commercially in many part of the world. Among the commercial flowers, gladiolus is one of the most common flower in India because of its

majestic spikes with attractive, elegant and delicate florets of various shades, sequential opening of flowers for a longer duration and good keeping quality of cut spikes. The major gladiolus growing countries are Holland, Germany, and the United States of America.

The cultivation of gladiolus in India dates back to 19th century as reported in 'Firmingers Manual of Gardening in India' published in 1863. It was mentioned that Charles Gray of Coonoor grew some gladioli from corms and seeds in his garden. Area and production of gladiolus in India is 11.16 thousand ha and 102.91 thousand ton respectively (NHB, 2014-15).

One of the important breeding approaches to create novel flower types in gladiolus is mutation breeding. Mutation plays an important role to induce variability which can be used for further cross breeding programmes. The concept of mutation was given by de Vries, 1901 and since then, many varieties in different crops have been evolved through artificially induced mutations Gutsafsson, 1947. Induced mutations are considered as an alternative to naturally occurring variations as the source of germplasm for plant improvement programmes and as an alternative to hybridization and recombination in plant breeding. The main advantage of mutation induction is that one or few characters of an otherwise outstanding cultivar can be changed without altering the remaining and often unique part of the genotype.

Gladiolus is highly heterozygous in its genetic constitution which makes it promising test material for induced physical mutagenesis. Mutation permits to increase the possibilities of creation of new material with novelties in flower colour, shape etc. Gamma rays and chemical mutagens have been used for genetic changes like high yield, more number of flowers, change in folour colour, shape, disease resistance, early maturity, etc. in ornamental plants. Gamma rays are known to influence plant growth and development by inducing cytological, genetical, biochemical, physiological and morphogenetic changes in cells and tissues.

Mutation is recognized as one of the most important technology for the development of new varieties through genetic manipulation. Mutation technique by using ionizing radiations and other mutagens have successfully produced a large number of new promising varieties in different ornamental plants. Mutation breeding has been successfully applied for varietal improvement of many crop species. About 70% of the world's mutant varieties have been induced through gamma-rays. The

possibilities of mutation breeding in vegetatively propagated species are favourable in general for various reasons due to large hetrozygosity of the material which allows direct detection of mutation in the irradiated material. In the vegetatively propagated material in which the intention is often improvement in visible characteristics, selection of potentially useful mutations is generally easy (Broertjis, 1968).

Developing new ornamental plants with improved floral attributes is a major goal of floriculture. The demand for novel flower colour, shape, sizes etc. are always very high in the market. That is why there is tremendous scope for developing novel flower types in gladiolus too. There was no report available on mutation breeding research on gladiolus in North Eastern region including Assam. So, novelties in flower and other desirable traits of gladiolus can be induced by gamma rays suitable for Assam and other North Eastern states. Keeping this in view the present investigation is undertaken with the following objectives:

1. To assess genetic variability for morphological and quality traits.
2. To study the association and causal relationship among the traits.
3. To assess the mutation frequency, mutagenic effectiveness and mutagenic efficiency of gamma rays.

CHAPTER II
REVIEW OF LITERATURE

Mutation techniques by using ionizing radiations and other mutagens have successfully produced and commercialized a large number of new promising varieties in different crops including ornamental plants worldwide. Studies have clearly proved that classical mutagenesis can be exploited for the creation of new and novel ornamental varieties of commercial importance. A large number of varieties have been developed in gladiolus through mutation breeding. Mutations in gladiolus are common especially in floret colour. Generally, the mutant is lighter in colour than the originals. The effects of physical mutagens on gladiolus have been studied by several workers. Since mutation breeding has been more successful in ornamental plants because changes in phenotypic characteristics like colour, shape or size of flower and chlorophyll variation in leaves can be easily detected. Mutation breeding is solely based on artificial mutations. This chapter deals with the earlier research work done on the similar lines and related to mutation breeding in gladiolus. Supporting evidences from other flower crops are also incorporated in the review for making interpretation of the results easier and broad based.

2.1 Gladiolus

Sheehan and Lorz (1960) conducted experiment on gladiolus cv ‘Spic and Span’ was subjected to 4 hours continous irradiation from (Co60) gamma rays, morphological abnormalities in foliage was reported in the form of leathery texture, wrinkled leaves and narrow leaves which increased with increase in exposure to gamma rays.

Isaev *et al.* (1960) investigated the effect of prolonged irradiation with Co60gamma irradiation on growth and cormlet production of gladioli. They have recorded that number of leaves; plant height, the number and size of newly formed cormlets were reduced, bearing lowest at the higher dosage and greatest in the lower dosage.

Dryagina (1962) treated eight cultivars of gladiolus with gamma rays and X-rays and 7 investigated there effects on growth, development and morphogenesis. In 'Summer Friday' cultivar stimulatory effects on germination and sprouting of corms was noticed. A dose of 10,000r of both gamma and X-rays sharply inhibited germination, growth and development of gladiolus.

Dryagina and Akhramova (1962) recorded several changes occurring through the chronic irradiation on a gamma field of gladiolus, marked reduction of floral parts and retardation of flower stalk morphogenesis were also induced through the treatments.

Dryagina (1964) observed that different gladioli cultivars reacted differently to irradiation treatments. In all the corms, formation of cormlets was reduced both in the years they were grown in the field and when they were grown without irradiation in subsequent year.

Iba *et al.* (1964) observed that plant growth, flowering and yield of cormlets of gladioli were reduced with the treatment of gamma irradiation. Abnormal inflorescence appeared because of the treatment. In the cultivar 'Spot Light' pure yellow petal colour which appeared in the X_1 generation inverted to the original flower colour in the X_2 generation. He also observed that inhibition of plant growth and chimeric variegation in leaf. In gladiolus cv. 'Blue Diamond' the floret colour changed from blue to white and in cv. 'Tajimanaru' from white to pink. In the cultivar 'Blue Diamond' full colour change of the floret from blue to white was also recorded through gamma irradiation.

Dryagina *et al.* (1965) stated that radiation dose is very effective for mutation breeding of gladiolus.

Moes (1966) studied that the dormant corms of the gladiolus cv. 'Hawaii' was irradiated with 2500, 5000, 10,000 and 15,000 rad of gamma rays. Number of surviving plants and spike per corms reduced after irradiation. Chimera in flower colour was recorded in 2 per cent of the spike in MV_1 generation.

M.Buiatti *et al.* (1969) conducted experiment on the fate of somatic mutations induced by γ-rays in *Gladiolus* var. Oscar was followed through the life of the

plant. Dormant corms were treated with 4000 R and 6000 R and mutation frequencies per plant and per flower order, as well as sector area distribution, were calculated. Mutated cell lineages could be traced through whole plants and diagrams were drawn. Data on mutated sector sizes suggested that a petal could derive from either 1,2 or possibly more initial cells. Mutations were found to cover more than one flower and to be induced before flower differentiation in the spike primordium of the dormant corms. Sector areas were greater and mutation frequencies lower in top flowers than in bottom flowers. The implications of these results in relation to Gaul's theory of diplontic selection are discussed.

Moes (1969) further treated corms of *Gladiolus gandavensis* with gamma rays and observed morphological abnormalities in foliage like narrow leaf, asymmetrical development of leaf, leathery texture, notching, sickle shaped leaf etc.

Uzenbaev *et al*. (1970) employed gamma irradiation in gladiolus with the doses of 5,10 and 25 Krad, which delayed sprouting by several days, and the dose of 5 and 10 Krad caused the most extensive morphological and physiological changes.

Grabowaska (1972) were irradiated gladiolus plants with 500, 1000 and 2000 R at V, VI and VII stages of organogenesis and recorded that in the first year early flowering was induced but with no change in flower colour, however lighter segments and spots on flower petals as micro changes were resulted with the treatments.

Grabowaska (1975) stated that due to irradiation treatments all the changes were not profitable in gladiolus cultivars and obtained only one plant with useful colour mutation.

Abraham *et al*. (1976) studied the effect of different doses of fast neutrons and gamma rays on the corms and cormlets of gladiolus cv. ‘Scarlet double’ and they have concluded that the gladiolus cormlets were less sensitive to the irradiation and survival at higher dose was greater than other bulbous ornamentals, and the fast neutron treatment was more effective.

Banerji *et al (*1981) conducted experiment in *Gladiolus psittacinus* var. Hookri cv. ‘Red’ and ‘Orange’ corms were irradiated with gamma rays 2.5 Krad to 12.5 Krad They have noticed reduction in sprouting, survival, plant height, sprout number,

leaves per corms, spike length and number of florets per spike as well as corm size. Chromosomal aberrations increased with increase in exposure to gamma ray.

Raghav *et al.* (1988) was studied the effects of gamma rays from ^{60}Co in three varieties of gladiolus, namely, 'Little Giant', 'Mansoer' and 'Wild Rose' irradiated at 1, 2.5, 5, 10 and 15 Krad doses at the Indian Institute of Horticultural Research, Bangalore. Percentage of sprouting was affected significantly at 10 and 15 Krad. LD_{50} was found to be between 10 and 15 Krad. Doses of 10 Krad and above proved to be detrimental for vegetative and floral traits. Plants treated with 10 Krad did not produce flower spikes, whereas the plants in 15 Krad treatment although sprouted but died afterwards. When treated with 10 Krad, plant height, leaf number and leaf-size were reduced significantly and leaves became narrow and leathery. Flowering was delayed significantly at 5 Krad. Radiation treatments caused decrease in spike length, number of florets per spike and floret size. A desirable and stable mutant with Shell Pink floret colour was isolated from the variety 'Wild Rose' in 1 Krad treament and it has been released as 'Shobha'.

B.K Banerji *et al*. (1994) conducted experiment on dormant corms of Gladiolus cv. White Friendship were irradiated with 250, 500, 750, 1000 and 1250 Gy of gamma rays. Reduction in survival, plant height, number of leaves and floret, spike length, leaf and corm size and delayed flowering were recorded after irradiation. Morphological abnormalities in foliage and florets and chromosomal aberration during root tip mitosis increased with increase in exposure. Flowering was ceased cent per cent in highest dose of 1250 Gy. LD_{50} on survival basis was found in 750 Gy exposure. MV_2 and MV_3 also followed the similar pattern of results as exhibited by MV_1 plants. Pink flower colour mutation was detected in few plants as sectorial chimeric form in MV_2 in treated population. In MV_3 one plant produced spike with lighter pink florets in 750 Gy treatment. This mutant has been isolated in pure form.

Kumar (1998) treated the *Gladiolus floribundas* cv. ‘Happy End’ with different doses of gamma rays and observed that number of days taken for sprouting of corms and survival percentage decreased with increase in gamma radiation.

Misra (1998) reported that four varieties of gladiolus viz. ‘Green Finch’, ‘Mayur, ‘Rose Memento’ and ‘Wind Song’ were subjected to 0.0, 15.0, 30.0, 45.0 and 60.0 Gy doses of gamma rays. The treated plants were studied in further vegetative

generations by putting these in observational rows from VM_2 to VM_8. Most of the variations appearing in VM_1 disappeared in further generations and the plant growth became normal afterwards.

Kasumi, M. (Ibaraki – ken. Plant Biotechnoloy Inst. Iwama, Japan) (2001) conducted a experiment for flower colour in which mutation breeding is known to be an effective means for obtaining novel varieties in days, mutant isolation has been restricted by the phenomenon of diplontic selection and subsequent chimera formation that was due to the multicellular origin of the plants. The purpose of this study was to established the method for obtaining solid mutants of gladiolus having novel colour by using gamma radiation and or tissue culture. Comparative studies on the capability of various explants sources for regenerating plants revealed that the cormel shoot apex was superior to the cormel pieces and leaf blades for its ability of embroyogenesis , cost of preparing materials and easiness to be handled. Histological observation confirmed that the induced regenerants were derived from adventitious embryos. There was varietal difference in the ability of somatic embryogenesis. The plants derived from cormel apices were almost identical with the original variety 'Traveler' in the flower characteristics compared. Thus, a simple and efficient culture system in gladiolus was established for obtaining regenerants by using cormel shoot apices as explants. Cantor *et al* (2002) irradiated the corm and cormels of three gladiolus cultivars 'Her Majesty', 'Applause' and 'Speranta' for 72 hrs with Cesium 137 gamma source on cylindrical exposure geometry. Significant effect in length of roots and growth tip was obtained at the variants which were irradiated with 1 Gy gamma radiation and 3 Gauss magnetic field.

N.S. Pathania (2002) was conducted a experiment on shoot clumps of gladiolus 'Eurovision' and 'Wine & Roses' multiplied in vitro were irradiated with different doses of ^{60}Co gamma rays. Survival of irradiated shoots decreased with increased dose of ^{60}Co gamma irradiation. A dose of 50 Gy had the lowest survival rate but was sub-lethal. Plants of 'Wine & Roses' and 'Eurovision' surviving this dose of gamma irradiation were multiplied on GMM-7 (MS medium + 2 μM KIN) and GMM-8 (MS medium + 4 μM KIN), respectively. In vitro selection by challenging with fusaric acid (1-1.5 mM) and culture filtrate (20 %) of *F. oxysporum* f.sp. *gladioli* resulted *Fusarium* yellows insensitive mutants at the end of the 3rd selection cycle. Ex vitro

evaluation further confirmed that fusaric acid and culture filtrate were suitable phytotoxins for selecting optimal resistance against fog.

Sudha D. Patil et al. (2009) studied on corms of three cultivars of gladiolus (*Gladiolus hybrids* L.) were exposed to seven doses of gamma radiations from 1kR to 7kR for induction of genetic variability. Most of characters were stimulated till 3kR treatment but started to reduce at higher doses whereas treatment of 2 kR proved better overall treatments including control. The doses of 6 kR and 7 kR proved injurious as the number of florets and length of spike reduced drastically in cv. American Beauty while plants remained blind in cvs. Nova Lux and Eurovision. Colour variation in florets and whole spike , increase and decrease in the number of florel organs and their fasciation and spike bifurcation were also observed from 4 kR to 7 kR treatments in all varieties. Three desirable colour mutants were obtained from three varieties and one mutant with bifurcated spike, having all similar character as original except doubled number of florets. Treatments of 5kR and 6kR were observed to be good for induction of mutants and a total of four mutants were isolated in VM_2 generation.

Tiwari *et al* (2010) irradiated four cultivars of gladiolus using gamma rays and observed significant increase in plant height and spike length at 5 kR while stunted growth of plant and spike length was recorded at 10 kR gamma ray irradiation and weight of corm and number of corm per plant were not affected significantly by gamma irradiation in any generation.

Swaroop *et al*.(2011) irradiated the gladiolus cultivar 'Snow Princess' with 0.0, 1.5, 2.0, 2.5, 3.0 and 3.5 kR doses. The results revealed that the corms treated with 3.5 kR shows significant result in plant height, while, length and number of leaves/plant get reduced significantly at higher doses of 3.0 kR and 3.5 kR respectively. Gladiolus corms were irradiated for induction of genetic variability. It was also observed that higher dose at 3.0 kR did not produce any florets at all, slightly colour changes from white to yellow white was also observed with increase in exposed of gamma rays.

Singh *et al.* (2013) carried out an experiment to study the effect of gamma irradiation on morphological characters of ten different varieties of gladiolus. It was observed that treatment with 2.0 kR gamma rays in cv. 'J.V. Gold' showed the best performance with respect of number of leaves per plant.

Bhajantri *et al.* (2014) treated gladiolus corms with 20 Gy gamma rays and found that spike length has significant positive association with weight of the corm, corm diameter, and plant height and floret diameter. These characters can be utilized as selection indices for high yielding genotypes.

Sudha D. Patil (2014) conducted an experiment in which influence of gamma radiation from Co –60 was studied in three varieties of gladiolus (*Gladiolus hybrid* L.) namely, American Beauty, Nova Lux and Eurovision irradiated with 1,2,3,4,5,6 and 7 kR doses and planted at Floricultural Farm, ASPEE college of Horticulture and Forestry,Navsari Agricultural University, Navsari. Percentage of sprouting and survival was affected significantly at 1 kR to 4 kR . LD_{50} was found to be beyond 7 kR dose for both sprouting and survival. Doses of 4 kR and above proved to be detrimental for various vegetative and floral traits. Plants treated with 6 kR and 7 kR did not produced flower spikes in cv. Nova Lux and Eurovision whereas cv. American Beauty had produced few flower spikes. When corms were treated with higher doses, plant height, leaf number and leaf size were reduced significantly and leaves become narrow leathery. Colour variations in florets and whole spike were also increased with increase in dose rate along with increase or decrease in number of floral organs. Radiation treatments at higher doses caused delayed in spike initiation with decrease in spike length, number and size of florets, vase life and yield per plot while lower doses responded positively. Three desirable mutants with light colours were isolated from all three varieties in 5 kR whereas one mutant have bifurcated spike at 6 kR from cv. American Beauty and they are isolated for further study in VM_2 genertion.

Anjana sisodia (2014) find out influence of various gamma doses i.e. 1.5, 2.5, 3.5, 4.5 and 5.5 kR along with untreated (control) in different varieties of gladiolus viz., Aldebaran, Jyotsana, Legend, Praha, Punjab Dawn, Pusa Kiran and Tiger Flame. Maximum number of opened florets in vase was recorded with control during 1st year, whereas during 2nd year it was higher with 2.5 kR. Among varieties maximum opened florets were exhibited with cvs. Jyotsana and Tiger Flame during 1st and 2nd, respectively. Gamma dose at 1.5 kR registered maximum number of opened florets at a time during both years. Longevity of first floret was more with 2.5 kR treatment. Maximum vase life was recorded with 5.5 and 2.5 kR during 1st and 2nd year respectively. Among the varieties, maximum vase life was recorded with cv. Punjab Dawn followed by cvs. Tiger Flame during 1st and 2nd years. Various morphological

changes were observed with different doses (3.5, 4.5 and 5.5 kR) and an unstable mutant in variety Pusa Kiran was observed at 2.5 kR. However, a stable mutant during 3rd year of investigation was recorded in cv. Tiger Flame at 3.5 kR gamma irradiation. This mutant has orange yellow colour flowers. Variation on flower shape, size and colour was exhibited than parent.

Kiran kumara (2015) used uniform and healthy corms of eight gladiolus varieties (Yellow Golden, Nathan Red, White Friendship, American Beauty, Red Majesty, Purple Flora and Algarve) were irradiated with different doses (0, 25, 40, 55 and 70 Gy) of gamma rays from Co-60 source and planted under open field condition in Randomized Block Design (RBD) with factorial concept. Each treatment was replicated thrice.Plants treated with higher doses (55 Gy and 70 Gy) showed deleterious effect of ionising radiations although at lowest dose (25 Gy) plants were not affected much. Plant height was reduced after irradiation as compare to untreated plants and was recorded minimum at highest doses. Number of shoots per plant was slightly increased at 25 Gy treatment (1.62) in VM_2 as compare to untreated plants (1.42). Significant effect of gamma irradiation on corm and cormel characters was noticed. Maximum number of corms per plant was recorded in plants treated with 25 Gy and minimum at 70 Gy. Among all the varieties Nathan Red had maximum number (1.75, 1.97) and weight (73.29gm, 79.33gm) of corms per plant in VM_1 as well as VM_2 generation. Number of cormels per plant was also reduced with the increase in gamma rays dose. Maximum number of cormels per plant (227.83) was recorded in the interaction of Algarve variety with 25 Gy gamma ray dose in VM_2. Homeotic mutants were isolated from all the varieties at 55 and 70 Gy except American Beauty and Red Majesty variety.

Kuldeep Sahariya *et al*. (2017) was studied the influence of gamma irradiations in ten varieties of gladiolus (*Gladiolus hybrida* L.) namely, Candyman Rose, American Beauty, Chandni, Red beauty, Punjab Morning, White Prosperity, Jester, Srijana, Psittacinous Hybrid and Priscilla were irradiated with 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5 and 5.0 kR doses. Earliest sprouting was recorded in 3.0 kr gamma treatment Production of corms was influenced due to various doses of' gamma irradiation during both years of investigation. Lower dose (1.5 kr) of gamma irradiation exhibited more number of corms per plant during first and second year, in comparison to higher doses and control. Similarly weight of corms per plant increased with lower doses of gamma irradiation in both years. Diameter of corms were influenced

significantly, whereas, lower dose (2.0 kr) resulted in bigger size of corm during first year (VM_1) and second year (VM_2). Maximum number of cormels per plant (31.61) was recorded in 2.0 kr dose of gamma irradiation.

Sudha Patil *et al.* (2017) investigated on "Induction of mutation through mutagens in gladiolus CV. American Beauty" was carried out at Navsari Agricultural University, Navsari (Gujarat). Corms ere treated with different does of gamma rays (5,6,7,8,9 and 10kr), EMS (0.5%,1.0%.1.5%) and DES (0.5%, 1.0% and 1.5%).Different vegetative , floral and yield characters were taken under study. Among all mutagenic treatments, early sprouting (10.40days) and flowering (72.73days) with maximum number of sprouts (2.27), plant height (58.86cm), number of leaves (12.87), leaf area(33.90cm^2), number of florets per spike (11.60), spike length(77.46cm),floret size (11.04cm), blooming period (11.27days), number of spikes per plant (2.13) and number of corms (1.53) was recorded in treatment T_7 i.e EMS @ 0.5%. Higher doses of all mutagens adversely affected growth, flowering and yield parameters of gladiolus.

Shukla (2017) used four gamma radiation doses i.e. 15 Gy, 30 Gy, 45 Gy, 60 Gy, and control (untreated) on three varieties of gladiolus viz., Candyman, American Beauty and Her Majesty. The results showed that variety Candyman had maximum sprouting percentage, plant height, number of leaves and leaf length, Whereas earlier days taken for sprouting, number of sprouts per corm and sprouting percentage was recorded maximum in variety American Beauty. Early spike initiation and days to first floret opening were recorded in variety Her Majesty. Spike length, number of florets per spike and floret diameter were significantly maximum in variety Candyman whereas, spike yield per plot and vase life of cut spike were significantly higher in variety American Beauty. Though maximum number of corms per plant were recorded in variety American Beauty, The number of cormels, weight of corms and weight of cormels per plant were maximum in variety Candyman. Maximum leaf abnormalities were recorded in variety Her Majesty but maximum morphologically abnormal plants were observed in variety Candyman. In case of gamma radiation doses, maximum sprouting percentage, survival percentage and leaf length were recorded in control (0 Gy i.e. unirradiated). Radiation dose of 15 Gy recorded maximum plant height at 25 and 75 DAS while, as 50 DAS plant height was maximum at control. Similarly 15 Gy gamma radiation recorded earlier days to spike initiation and first floret opening whereas, floret diameter was recorded maximum at no radiation. Maximum

number of florets, spike length, yield of spike per plot and vase life of cut spike were recorded at 15 Gy. Higher dose of 60 Gy recorded maximum abnormal plants whereas, no abnormal plants were observed in control. Various changes in form of spike length, spike doublness, and floret colour were recorded after radiation treatment in the form of variants and chimeras.

Dhawani Patel *et al*. (2017) studied on gladiolus variety 'Pssitacinus Hybrida' to know the best mutagen between physical mutagen (gamma rays) and chemical mutagen (DES). The experiment was carried out at Floriculture Research Farm, ASPEE college of Horticulture and forestry, Navsari during the 2013- 2014.The corms of gladiolus were treated with different does of gamma rays viz. 5.5 kR, 6.0kR, 6.5kR, 7.0kR, 7.5kR, and 8.0Kr and different concentrations of DES 0.1%, 0.2%, 0.3%, 0.4%, and 0.5%. Different vegetative and flowering characters were taken under study. It was observed that there was negative correlation of sprouting and survival per cent with the different treatments and it was also noticed that survival per cent of DES treated corms was less compared to gamma rays. Looking at vegetative characters it was found that DES had more pronounced effect on vegetative characters similarly for flowering characters DES produced larger spikes and with more no. of florets as compared to Gamma rays were more responsive to treatment of DES as compared to gamma rays.

Abhilash Shukla *et al*. (2018) was conducted a experiment during the Rabi season of 2016 to study the effect of gamma rays on flowering and vase attributes associated with mutation and purification of novel types in gladiolus. The corms were treated with gamma rays (source 60Co) at the dose of 15, 30, 45 and 60 Gy and were sown in the field along with the control (Un- irradiated corms) . Low doses of gamma irradiation resulted in hormesis and induced encouraging vase life and novalities in flowering while the higher doses induced higher degree of abnormalities which led to mortality and blindness. Six variants were also obtained exhibiting variation in spike length (cv. Candyman treated with 15 Gy), spike duoblness (cv. Candyman treated with 45 Gy), change in floret colour (cv. American Beauty) and cv. Her Majesty treated with 30, 45, 60 Gy respectively.

Manisha Kashyap *et al*. (2018) was carried out a experiment at Department of Floriculture and Landsacape Architecture, College of Agriculture, Indira

Gandhi Krishi Vishwavidyalaya, Raipur during 2017-18. The experiment was designed in Randomized Block Design with Factorial concept using VM_2 generation of three gladiolus cultivars viz. Candyman, American Beauty, Her Majesty irradiated previous year with four doses of gamma radiation 15 Gy, 30 Gy, 45 Gy, 45 Gy, along with 0 Gy (control) to investigate the effect of effect of gamma radiations. The results revealed early spike initiation (77.80) in variety Her Majesty. Minimum days for opening of first floret (100.86) were observed in var. American Beauty whereas maximum leaf abnormality percentage was observed in var, Her Majesty. Leaf abnormality percentage and morphological abnormalities percentage were found maximum at higher dose 60 Gy. Two variants from var. Candyman iiradiated at 45 Gy and 60 and one variant from var. Her Majesty irradiated at 30 Gy were identified and isolated for changes in floret color whereas one variant identified and isolated from var. American Beauty having variation in floret arrangement.

2.2 Other flower crops

Arnold *et al* (1998) studied the effect of various gamma doses on the four cultivars of miniature roses and found that radiation significantly decreased the mean number of spines per 10 cm of stem length at 50 Gy and increased the mean petiole length at 50 and 100 Gy in‘Portluck’ cultivar although it reduced mean spine number in ‘Mountie’ cultivar. Mean petalnumber in ‘Blue Blood’ cultivar was significantly reduced at 50 and 200 Gy. Plant height decreased with increase in dose of gamma rays in all the four cultivars of rose i.e ‘Portluck’,‘Blue Blood’, ‘Mountie’ and ‘Dark Red Mountie’ and none of the plant growth parameterswere affected by the radiation doses studied in ‘Dark Red Mountie’ cultivar nor were the length and width of the terminal leaflet of any of the cultivars.

S.K Dutta *et al.* (2001) used rooted cuttings of *Dendranthema grandiflorum* cv. ‘Puja’ were treated with different doses of gamma rays. Sectorial somatic mutations both in flower colour and shape were detected in all the doses. The original floret colour of ‘Puja’ is red-purple and florets are flat spoon shaped. One of the mutant floret colour was yellow-orange with original flat florets and another mutant floret colour was yellow-orange with tubular florets. Original and mutated ray florets were cultured on agar-solidified Murashige and Skoog basal medium supplemented with sucrose and different combinations of 1-naphthaleneacetic acid (NAA) and

6-benzylaminopurine (BAP). Direct shoot organogenesis was seen within 2 weeks of culture initiation. The best regeneration was obtained on medium supplemented with 1 mg/l BAP + 0.5 mg/l NAA. Shoots regenerated from all explant types were rooted *in vitro* and transferred to the field. Regenerated plants flowered true-to-explant floret colour and shape. The isolated yellow floret colour mutants and yellow floret colour mutants with tubular florets were maintained vegetatively and have proved to be true to type in two successive generations.

Rather *et al.* (2002) treated the uniform sized bulbs of Dutch iris (*Iris hollandica* cv. 'Prof. Blaauw') with different doses of gamma rays and observed that sprouting of bulbs was delayed by 60 days in VM_1 generation and only 9 days in case of VM_2 generation. The bulb survival reduced by 30.52% in VM_1 generation as compared to non significant reduction in VM_2 and maximum reduction was noticed in leaf length and plant height whereas minimum in leaf width and number. Maximum reduction was observed in spike length and floret number whereas minimum in length of fall and standard petals.

Mishra *et al.*(2003) worked on Flowers of *Chrysanthemum morifolium* Ramat cv. Lalima were greyed red and florets were flat spoon shaped. Ray florets after inoculation on the Murashige and Skoog's medium supplemented with 1.07 μM α-naphthaleneacetic acid and 8.87 μM benzyladenine were irradiated with γ-radiation (0.5 Gy and 1 Gy). All the regenerated shoots either from control or from γ-irradiated florets were isolated, rooted and transplanted in the field after hardening. Two mutants were obtained in the γ-irradiated plants (0.5 Gy). Both the mutants were yellow coloured but one having flat spoon shaped ray florets similar to the original cultivar, while the other having tubular florets. Both the mutants were propagated vegetatively and have produced true-to-type flowers.

Kole *et al.*(2005) treated the two varieties of zinnia viz. 'Suttons Giant Double Orange and 'Yellow' with gamma rays using Co_{60} in gamma cell and found significant increase in plant height, number of branches and pedicel length over control at 5 kR followed by decrease onwards 10 kR in cv. 'Yellow'. However, in 'Orange' variety the increase in plant height at 5 kR was non-significant. One plant had circular leaves at one of its branch which indicated sectorial mutation at 5 kR in 'Yellow' variety.

S.K Datta (2005) worked on *Chrysanthemum morifolium* Ramat. cvs. Flirt, Puja, Maghi and Sunil were treated with 500 and 1000 rad gamma rays and cultured on MS medium supplemented with different concentrations and combinations of growth regulators. The frequency of direct shoot regeneration decreased in gamma-ray-treated florets. Radiation effect was found on plant-regeneration from gamma-ray-treated floret explants and also on plant height, size of leaf and flower. Five solid flower colour/floret shape mutants with slight changes in ray floret morphology have been detected and established. In vitro mutagenesis through direct regeneration helped in the development of solid mutants without diplontic selection in a relatively short period of time.

Berenschot *et al.* (2008) irradiated the seeds of the petunia with different doses of gamma rays and observed most significant reduction in height at 40 and 60 Gy of gamma irradiation. Plant surviral rate and the frequency of morphological effects at the adult vegetative stage were 9 higher for the M_1 population derived from gamma irradiation treated seeds.

Misra *et al.* (2009) irradiated the rooted cuttings of chrysanthemum cultivar 'Pooja' with gamma rays and observed that number of branches per plant, plant spread, number and size of leaf got reduced after irradiation and with increase in exposure. Frequency of leaf abnormalties increased with increased in exposure to gamma rays. The maximum leaf abnormalties were recorded after treatment with 25Gy.

Mubarok *et al.* (2011) irradiated tuberose with five doses of gamma rays (0, 25, 50, 75 and 100 Gy) and observed that more than 25 Gy reduced bulb growth less than 30%.

Kolar *et al.* (2011) performed an experiment using gamma rays in delphinium to induce chlorophyll mutation and observed that out of the 11 different types of mutations maximum (10) was induced by 10 kR gamma rays treatment followed by 5 kR and among the mutants recorded, viridis type was most predominant followed by xantha and striata. The mutants contained significantly less chlorophyll than normal plants. Among the mutants, xantha and aurea contained the least chlorophyll and those of chlorina the most.

Tiwari *et al*. (2011) studied gamma rays induced morphological changes in pot marigold (*Calendula officinalis*) and observed higher percentage of survival at lower doses and poor survival at higher doses in all the generations of *Calendula officinalis*. However, reduced survival upto second generation (M_2) and no survival after that were exhibited byplant treated with 5 kR gamma rays.

Kumar *et al*. (2012) carried out *in vitro* mutation induction and selection of chrysanthemum lines with improved resistance to *Septoria obese* and observed that the percentage of surviving calli decreased with the increasing gamma ray doses. No calli was recovered at gamma rays dose 30 Gy while 22.2% of the calli survived at 20 Gy dose of gamma irradiation.

Kiran Kumari *et al.* (2013) studied induced mutagenesis in Chrysanthemum morifolium variety 'OTOME PINK' through gamma irradiation in which rooted cuttings of Chrysanthemum variety 'Otome Pink' were treated with 0,10,15 and 20 Gy of gamma rays and evaluated for various morphological, palynological and anatomical characters.Plant survival, plant height, number of flower heads, stems per plant,stem diameter and leaves per plant reduced after gamma irradiation.The delayed flowering and plant in vegetative stage were observed at 20Gy gamma irradiation dose. Pollen fertility, number of chloroplasts per guard cell, flower head size and fresh weight also decreased as the dose increased. The leaf abnormalities were observed in terms of changes in leaf shape, leaf size, leaf margin and leaf apex.Flower head fascination and asymmetrical development of flower heads increased with increased with increased with increased dose of gamma irradiation. Various changes in flower colour and shape were recorded after treatment in the form of chimeras. Two variants, one at 10 Gy having yellow colour and other at 15 Gy having quiled petals were obtained and further multiplied vegetatively.

M B Pohare *et al*. (2013) observed effect of gamma radiations on the Morphological characters in vitro regenerated Polianthes tuberose in which the local cultivar , with five different doses of gamma radiations (10, 20, 30, 40 and 50Gy). No significant differences were observed in the survival rates among the untreated (control) and treated plants with different doses of gamma irradiation .But significant differences wre recorded in the plant morphological characters upon gamma radiation treatment of

30Gy in terms of plant height, number of leaves, leaf size and colour as compared to the control plant.

Manish Kapoor *et al.* (2014) was conducted an experiment during the kharif season of 2010 – 2012 to study hormonies , morphological and biochemical attributes associated with mutation and purification of novel types in corn marigold. The seeds of Glebionis segetum were treated with gamma rays (Source ^{60}Co) at the dose of 20, 40, 60, 80and 100Gy were sown in the field along with control (un –treated seeds). Low doses of gamma irradiation resulted in hormesis and induced encourages novelties, while the higher doses induced higher degree of abnormalities which led to mortality. The M_2 seeds were sown to observe their characters and mutants in each population.

K. Kayalvizhi *et al*. (2017) worked for improvement of tuberose var. Prajwal through mutation breeding. The bulbs were treated with gamma rays, diethyl sulphate (DES) and ethyl methane sulphonate (EMS). The treatments consisted of 0.5, 1.0, 1.5, 2.0 and 2.5 kR of gamma rays, 15, 20, 25 and 30 mM of DES and 30, 45, 60 and 75 mM of EMS and control (untreated). Various morphological and floral characters were observed. In general, the treated population had manifested reduced expression than the control (untreated population) for most of the morphological and floral characters. Higher the dose of mutagens, lower was the expressivity of the traits. Expression of the morphological characters namely plant height, number of leaves, leaf length, leaf width and leaf thickness increased in the lower doses and decreased in the higher doses in M_1V_2 generation.

U H Patil *et al.* (2017) was conducted experiment on chrysanthemum cultivar ‘Local Golden’ which was irradiated with 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 Krad of gamma radiation. Reduction in survival percentage, plant height, number of branches, number of suckers per plant was observed after irradiation and with increase in dose of gamma rays. The LD_{50} is between 2.5 and 3.0 Krad. Plant height at time of bud initiation and flowering was maximum in control (45.29 cm and 79.90 cm, respectively), while minimum in 2.5 and 3.0 Krad treatments. Chimera in ray florets of flower was observed in one plant after 1.5 Krad treatment. The original shape of ray florets was flat with small tube at the base whereas in case of tubular mutant, shape at tip was spoon type and basal portion showed pipe or tube like appearance.

CHAPTER III

MATERIALS AND METHODS

The present investigation on ‘‘Studies **on induced mutation in gladiolus (*Gladiolus hybrida* L.) through gamma rays’’** was conducted during 2017-19. The details of experimental materials and methods adapted during the course of investigation are described below.

3.1 EXPERIMENTAL SITE

The experiment was conducted was conducted at Instructional Cum Research Farm (ICR), Assam Agricultural University, Jorhat during 2017-18 and 2018-2019. Jorhat is situated in the upper Brahmaputra valley zone of Assam. Geographically the farm is situated at 26^0 46’ N latitude and 94^0 13’ E longitude and 86.6m above the mean sea level.

3.2 CLIMATIC CONDITION

The climate in Jorhat is subtropical humid. The meteorological data relating to the cropping season are given in Annexure 1.

3.3 EXPERIMENTAL MATERIAL

The experimental material for the present investigation comprised of four cultivars of gladiolus are shown in Plate 1.

1. Red Candiman
2. Pasibica Beauty
3. Summer Sunshine
4. Red Majesty

Gladiolus is vegetatively propagated by corms. The healthy corms of 3.5-4.5 cm size of these varieties were selected for mutagenic treatment.

3.4 PREPARATION OF EXPERIMENTAL SITE

Land was brought to a good tilth by ploughing and then levelling. Cow dung was properly incorporated in the field at the time of field preparation.

Red Candiman

Pasibica Beauty

Summer Sunshine

Red Majesty

Plate 1 : Varieties used in experiment

3.5 EXPERIMENTAL METHODS AND LAYOUT PLAN

The experiment was laid out in Factorial Randomized Block Design (FRBD) with three replications. The corms of uniform size were used for treatment of gamma irradiation and treated with gamma rays in the gamma chamber and then planted in the beds with a spacing of row to row 40 cm and corm to corm 30 cm. The details of layout are as follows:

1.	Number of doses	-	6 (including 0 Gy as control)
2.	Number of varieties	-	4
3.	Number of treatments	-	24
3.	Number of replication	-	3
4.	Spacing	-	40cm × 30cm
5.	Design of layout	-	Factorial Randomized Block Design

3.6 IRRADIATION TREATMENTS

Four varieties of gladiolus viz. Red Candiman, Pasibica Beauty, Summer Sunshine and Red Majesty were irradiated with gamma rays with five doses viz. 20Gy, 30Gy, 40Gy, 50Gy, 60Gy at Bidhan Chandra Krishi Vishwavidyalaya, West Bengal and planted during Rabi 2017. Untreated corms of gladiolus were taken as control. Treated and untreated corms of each variety were planted in each plot for the comparison. Observations were recorded for different growth and flowering characters. During second year of experimentation i.e M_1V_2 generation the corms harvested from the first year experiment i.e M_1V_1 generation were planted during Rabi 2018 in the same method for recording the observations in similar manner.

3.7 CULTURAL OPERATION

3.7.1 Weeding and irrigation

Hand weeding was done periodically to keep field free from the weeds. Earthing up was done as and when needed. Three hoeing and weeding were done as and when required. Crop was irrigated immediately after planting and the plants were given uniform irrigation thereafter at an interval of 10-15 days in winter months and at an interval of 6 to 7 days in summer months. These cultural operations were uniformly done for all the treatments and replications.

3.7.2 Fertilizer application

In addition to application of FYM @ 10 kg /m^2 application, nitrogen @ 50 g/m^2 was applied in three split doses at the time of planting, third leaf stage and sixth leaf stage. Phosphorus (20 g/m^2) and potassium (20 g/m^2) were given as basal. Nitrogen, phosphorous and potassium were applied in the form of urea, single super phosphate and muriate of potash.

3.7.3 Earthing up

Earthing up was done at third and sixth leaf stage to provide sufficient support, greater soil volume for spread of corms and prevent lodging of plants.

3.7.4 Plant protection measures

To control caterpillars and leaf miner as well as other foliage insects, 0.15 % monocrotophos was sprayed whenever it was necessary. To control the *Fusarium* wilt, soil drenching with 0.2% carbendazim was done one week before planting corms and it was applied twice in standing crop.

3.8 OBSERVATIONS RECORDED

Five randomly selected plants per replication in each treatment were tagged for recording observation on different growth and flowering characters.. The study was undertaken with respect to following characters. The details of technique followed for recording the observations were as follows.

3.8.1 Days to sprouting (DS)

Days taken to sprouting were recorded from the days after planting of corms to sprouting.

3.8.2 Plant height (PH)

Plant height was measured in cm from ground level to the tip of the plant when the top most floret of the spike opened fully.

3.8.3 No. of leaves (NOL)

Number of leaves per plant was counted at the time of spike initiation and number of leaves per plant was calculated.

3.8.4 Breadth of leaf (BOL)

The length of randomly selected leaf was measured with the help of scale at the peak flowering stage and their average was calculated.

3.8.5 Days to spike initiation (DSI)

Days taken to spike emergence were recorded from the days after planting of corms to emergence of the spike.

3.8.6 Spike length (SL)

The spike length of the spike was measured in cm from the first node below the lowermost floret up to tip of the spike after opening of last flower and worked out in cm.

3.8.7 Rachis length (RL)

The rachis length was measured with help of scale in cm from the basal floret to the tip of the last floret in a spike value was presented in cm.

3.8.8 No. of floret per spike (NOF)

Total number of floret produced in each spike of the observation plants were recorded after opening of the last floret of the spike.

3.8.9 Length of floret (LOF)

The length of second floret of the spike was measured with the help of scale in cm at the flowering stage and their average was calculated.

3.8.10 Breadth of floret (BOF)

The breadth of floret was measured from the second floret of the spike of five randomly selected plants with the help of scale and worked out in cm and their average was calculated.

3.8.11 Vase life (VL)

Vase life of gladiolus spikes was observed in distilled water. The spike was plucked when 50% of the florets became fade and immediately kept in vase for study.

3.8.12 No. of spikes per plant (NOS)

Total number of spike produced in each plant were recorded at flowering stage.

3.8.13 Flower colour

By visual observation.

3.9 STATISTICAL ANALYSIS

The mean data of each characters were statistically analyzed by using Factorial Randomized Block Design. The critical differences at 5 percent and 1 percent level of significance for each character were worked out for comparing the significance among the treatment means. The result was presented in the form of tables and was given at appropriate places for result interpretation.

3.9.1 Analysis of Variance : The structure of analysis of variance table is as follows:

Source of variation	Degree of freedom	SS	MS	F
Replication	r-1	RSS	RMS=RSS/(r-1)	RMS/ErMS
Factor A	m-1	ASS	AMS=ASS/(m-1)	AMS/ErMS
Factor B	n-1	BSS	BMS=BSS/(n-1)	BMS/ErMS
Interaction (A X B)	(m-1)(n-1)	ABSS	ABMS=ABSS/(m-1)(n-1)	ABMS/ErMS
Error	(r-1)(mn-1)	ErSS	ErMS=ErSS/(r-1)(mn-1)	
Total	Mnr-1	TSS		

If the cal. F (For A) > $F_{0.05\ ;(m-1)(r-1)(mn-1)}$ then H_{01} is rejected. This means the main effects due to the factor A are not all equal to zero. Similarily, $H_{02,}$ H_{03} and H_{04} are rejected if the calculated are rejected if the calculated value of F > table value of $F_{0.05}$ with corresponding d.f. If the main effects and or the interaction effects are significant then we calculate the critical difference (CD) / least significant difference (LSD).

3.9.2 Estimation of variability parameters

Genetic parameters were estimated for each character from ANOVA. Genotypic variances (σ^2_g), phenotypic variance (σ^2_p) and environmental variance (σ^2_e) were computed according to Burton and Devane (1953). Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were estimated from these variances in terms of standard deviation as percentage of the grand mean. Heritability (h^2) in broad sense was calculated following Burton and Devane (1953). The expected genetic advance was calculated by using the formula suggested by Johanson, Robinson and Comstock (1955). Genetic advance was then expressed as percentage of the grand mean variability was calculated for each of the parameters under study as follows:

3.9.3 Genotypic variance (σ^2_g)

This was computed according to Burton and Devane (1953) as given below:

$$\sigma^2_g = \frac{M_g - M_e}{r}$$

Where, M_g = Mean square due to genotype

M_e = Mean square due to error

r = number of replication

3.9.4 Phenotypic variance (σ^2_p)

This was computed for each trait under study by using the following formula :

$$\sigma^2_p = \sigma^2_g + \sigma^2_e$$

Where, σ^2_e = Error variance or error mean square (M_e).

3.9.5 Genotypic co-efficient of variation (GCV)

This was calculated by using the formula given by Burton (1952) as follows:

$$GCV = \frac{\sqrt{\sigma_g 2}}{\bar{X}} \times 100$$

3.9.6 Phenotypic co-efficient of variation (PCV)

This was calculated by using the following formula given by Burton (1952):

$$\text{PCV} = \frac{\sqrt{\sigma_{p^2}}}{\bar{X}} \times 100$$

3.9.7 Heritability (h_{bs}^2)

Heritability in broad sense is the ratio of genotypic variance ($\sigma^2_{g)}$ to the phenotypic variance ($\sigma^2_{p)}$ expressed in percentage. It was calculated by using the formula by following Burton and Devane (1953) as follows:

$$h^2 = \frac{\sigma^{2g}}{\sigma^{2p}} \times 100$$

3.9.8 Expected genetic advance (GA)

Expected genetic advance for each character was calculated by using the formula suggested by Johanson, Robinson and Comstock (1955) as:

$$GA = k.\ \sigma_{p.}\ h^2$$

Where, K = 2.06; constant for 5% selection intensity

σ_p = Phenotypic standard deviation

h_{bs}^2 = Heritability in broad sense.

Genetic advance as percent of population mean = $\frac{GA}{\bar{X}} \times 100$

X = Mean of base population

3.9.9 Correlation studies

The genotypic and phenotypic correlation coefficients between two characters say X and Y under study were calculated. For this data was subjected to the analysis covariance and the respective correlation coefficients were computed using the following formula (as explained Singh and Choudhary, 1979):

3.9.10 Genotypic correlation coefficient (r_{gxy})

$$r_{gxy} = \frac{\sigma_{gxy}}{\sqrt{\sigma^2{}_{gx}} \times \sqrt{\sigma^2{}_{gy}}}$$

Where, r_{gxy} = Genotypic correlation coefficient between x and y.

σ^2_{gx} = Genotypic variance of x

σ^2_{gy} = Genotypic variance of y

σ_{gxy} = Genotypic covariance between x and y and it is given by

$$\sigma_{gxy} = \frac{MSP_g - MSP_e}{r}$$

Where, MSP_g = Genotypic mean sum of product

MSP_e = Error mean sum of product

r = Number of replication

3.9.10 Phenotypic correlation coefficient (r_{pxy})

$$r_{pxy} = \frac{\sigma_{pxy}}{\sqrt{\sigma^2_{px} \times \sigma^2_{py}}}$$

Where, r_{pxy} = Phenotypic correlation coefficient between x and y.

σ^2_{px} and σ^2_{py} = Phenotypic variances of x and y respectively

σ_{pxy} = Phenotypic covariance between x and y and is given by

$\sigma_{pxy} = \sigma_{gxy} + \sigma_{exy}$

The significance of correlation coefficient was tested by comparing the observed value of correlation coefficient with the table value at 5 per cent and 1 per cent probability level with (n-2) degree of freedom for its significance where 'n' is the number of genotypes.

3.9.11 Path coefficient analysis

Path coefficient analysis was carried out using the simple correlation coefficient to know the direct and indirect effects of the yield components on fruit yield as suggested by Dewey and Lu (1959). Thus, the correlation coefficient of any character with fruit yield was split in to direct and indirect effects adopting the standard formula

$$r_{iy} = r_{1i}p_1 + r_{2i}P_2 + r_{3i}P_3 + \ldots\ldots\ldots\ldots + r_{ni}P_n + \ldots\ldots\ldots r_{ii}P_1$$

Where,

r_{iy} = Correlation of the character on fruit yield

$r_{1i}p_1$ = Indirect effect of ith character on fruit yield through first character

$r_{ni}P_n$ = Correlation between n^{th} and i^{th} character

n = Number of independent variables

P_i = Direct effect of the ith character on the fruit yield

Direct effect of component characters on seed yield were obtained by solving the following equations-

R_{ry} = (P_{1y}) (r_{ij}) which can also be calculated as

Where, (P_i) = (r_{ij})-1(r_{ij})

(P_i) = Matrix of direct effect

(r_{iy}) = Matrix of correlation coefficients among all the n components characters

(r_{il}) = Matrix of correlation of all component characters with fruit yield

r_{il} = Indirect effect of 1 character fruit yield through first character

The residual effect was obtained by the following formula:

Residual effect= $P_r = (1-P_{ij}r_{iy})^{1/2}$

Where, P_{ij} and r_{iy} are given above.

3.10 Mutation frequency, Mutagenic effectiveness and Mutagenic efficiency

In the present investigation different kind of mutations were recorded on the basis of formation of chimeras, shape etc. changes in colour and survivability. Mutation frequency (cm) was calculated as the percentage of mutated plants. Both mutagenic effectiveness and mutagenic efficiency were calculated on the basis of formula suggested by Konzak *et al.*(1965).

$$\text{Mutagenic Effectiveness} = \frac{M}{\text{Doses of mutagen (krad)}}$$

$$\text{Mutagenic efficiency} = \frac{M}{L}$$

Where,

M = Mutation Frequency expressed as percentage.

Krad = Kilorad

L = Percentage of reduction in survival (Biological damage).

CHAPTER IV

EXPERIMENTAL FINDING

The Present experiment entitled **''Studies On Induced Mutation In Gladiolus (*Gladiolus hybrida L.*) Through Gamma Rays''** was carried out during 2017-2018 and 2018-2019. Experiment was conducted at Instructional Cum Research Farm of Department of Plant Breeding and Genetics, Assam Agricultural University, Jorhat, Assam. Most of the changes appearing in M_1V_1 and many of colour changes disappeared in M_1V_2. All parameters of gladiolus were analyzed statistically during $M_1V_1$and M_1V_2 generations and presented under the following headings. Each character under study was described with the help of Tables, whereas, some important characters were described with the help of figures also.

4.1 Genetic variability

The analysis of variance is presented in Tables 4.1 and 4.2. for M_1V_1 and M_1V_2 generations for four varieties for different growth and flowering characters.

Analysis of variance for the factorial randomised block design with respect to four variety of gladiolus revealed significant differences among the material used in the investigation for all the 12 characters except number of leaves per plant. The character studied were days to sprouting, Plant height , days to spike initiation , breadth of leaf, length of floret, breadth of floret, spike length, number of spike per plant, rachis length , number of florets per spike, days to sprouting, vase life. Significant amount of variation was observed among the genotypes and validated for further genetic analysis.

4.2 Genetic parameters

To determine the magnitude and nature of genetic variation present in the populations, genotypic coefficient of variation, phenotypic coefficient of variation, heritability in broad sense and expected genetic advance as percentage of mean were obtained from the analysis of variance.

Table 4.1 .Analysis of variance for different traits in gladiolus for M_1V_1 generation

SOURCE	DF	DS	PH	NOL	BOL	DSI	SL	RL	NOF	LOF	BOF	NOS	VL
Replication	2	0.07	33.28	0.26	0.17	0.54	3.45	23.93	1.81	1.67	0.26	0.12	0.45
Treatment	23	73.79**	1742.22**	13.56	0.59**	222.89**	9617.77**	238.27**	25.97**	2.57**	6.89**	0.19**	12.55**
Variety	3	3.13**	3513.17**	51.90	1.43**	233.67**	237.87**	50.84**	23.63**	0.95**	1.04**	0.27**	7.08**
Dose	5	335.68**	5388.87**	5.62	1.33**	857.66**	1697.88**	1048.40**	89.80**	7.63**	27.73**	0.54**	52.44**
V X D	15	0.63**	172.49**	8.54	0.17**	9.14**	47.73**	5.72**	5.16**	1.21**	1.11**	0.05**	0.35**
Error	46	0.15	137.98	0.77	0.04	3.19	13.14	6.80	1.10	0.38	0.24	0.05	0.16
CV (5%)		7.03	12.46	10.08	8.23	2.64	5.44	11.25	10.30	6.74	5.34	23.36	2.49

** Significant at P =0.01

* Significant at P = 0.05

TABLE 4.2.Analysis of variance for different traits in gladiolus for M_1V_2 generation

SOURCE	DF	DS	PH	NOL	BOL	DSI	SL	RL	NOF	LOF	BOF	VL	NOS
Replication	2	0.12	16.07	0.87	0.10	1.62	61.16	27.40	1.988	0.11	0.23	0.01	0.09
Treatment	23	77.46**	11453.71**	6.33	0.59**	25176**	1284.11**	240.41**	22..46**	0.93**	9.55**	11.42**	1.11**
Variety	3	6.62**	1577.827**	10.04	1.42**	229.81**	442.16**	54..01**	1.67**	0.23**	4..04**	1.20**	1.21**
Dose	5	214.28**	1611.61 **	13.04	1.34**	977.62**	5206.73**	1054.76**	98.03**	2.38**	40.43**	50.75**	4.08**
V X D	15	46.02**	49.53**	3.35	0.17**	14.20**	144.96**	6.24**	1.43**	0.58**	0.36**	0.35**	0.09**
Error	46	0.35	81.33	150.69	0.04	3.15	16.85	6.40	0.42	0.39	0.11	0.17	0..03
CV (5%)		4.02	9.36	6.65	6.08	2.68	6.03	6.39	5.64	6.36	3.80	6.04	13.42

** Significant at P =0.01

* Significant at P = 0.05

The value of GCV and PCV values were categorised as low, medium and high as follows-

0 - 10%- Low

10 - 20%- Moderate

>20%- High

The heritability values were categorised as low, moderate and high as follows-

<60% - Low

60 – 80% - Moderate

>80% - High

Genetic advance was categorised as low, moderate and high as follows-

<20% - Low

20 – 30% - Moderate

>30% - High

M_1V_1 generation

The value for genotypic coefficient of variation was highest for spike length (84.93%) followed by no. of spike per plant (54.84%). Moderate values of GCV were recorded for rachis length, days to sprouting, vase life, plant height, breadth of floret and days to spike initiation.

Phenotypic coefficient of variation was highest for spike length (85.11%) followed by no. of spike per plant (59.61%). Moderate values of PCV were recorded for rachis length, plant height, days to sprouting and vase life.

All the characters under study except length of floret showed moderate to high heritability in broad sense. Among the characters, the highest estimate of heritability was exhibited by days to sprouting, vase life, days for spike initiation. The characters no. of floret per spike, no. of spike per plant, plant height showed high estimates of heritability.

The highest estimation of genetic advance as percent of mean was exhibited by vase life (70.30%). High to moderate values for genetic advance was also recorded for the characters of days to sprouting, spike length, no. of floret per plant,

Table 4.3. Estimation of genetic parameters for different traits in gladiolus for M_1V_1 generation

Character	Mean	Range	±Sem	GCV(%)	PCV(%)	Heritability(%)	GA (%)
DS	15.69	22-8.46	0.32	31.56	31.66	99.3	64.82
PH	94.25	50.46- 117.25	6.59	24.53	27.51	79.48	45.06
BOL	2.64	2.08-- 3.59	0.17	16.08	18.06	79.23	29.49
DSI	67.48	52- 75.60	1.47	12.68	12.95	95.81	25.57
SL	6 6.61	34.07- 99.65	2.96	84.93	85.11	95.59	61.23
RL	2 3.18	13.55 - 32.95	2.12	37.88	39.52	91.89	44.88
NOF	1 0.20	5.85 - 14.67	0.85	28.22	30.04	88.23	54.60
LOF	9.22	6.92- 11.19	0.50	9.25	11.45	65.28	15.40
BOF	9.18	6.25 - 12.06	0.23	16.22	17.07	90.20	31.73
VL	5.83	2.27-9.26	0.33	34.81	35.52	96.07	70.30
NOS	0.95	1-1.56	0.18	54.84	59.61	84.63	32.40

rachis length, plant height, days to spike initiation, breadth of leaf, breadth of floret and no. of spike per plant.

High GCV coupled with high heritability was observed for spike length. Moderate heritability coupled with high genetic advance was observed for plant height and breadth of leaf. High heritability coupled with high genetic advance was observed for vase life, days to sprouting, spike length, rachis length and no. of floret per plant. Length of floret were characterized by moderate heritability with low genetic advance.

M_1V_2 generation

The value for genotypic coefficient of variation was highest for plant height (63.90%) followed by no. of spike per plant (45.86%), days to sprouting, spike length, vase life, rachis length and no. floret per spike. Moderate values of GCV were recorded for breadth of leaf, breadth of floret, days to spike initiation.

Phenotypic coefficient of variation was highest for plant height (64.58%) followed by no. of spike per plant (47.78%) , spike length, days to sprouting, vase life, rachis length and no. of floret per spike. Moderate values of PCV were recorded for breadth of leaf, breadth of floret and days to spike initiation.

All the characters under study except length of floret showed moderate to high heritability in broad sense. Among the characters, the highest estimate of heritability was exhibited by days to sprouting, spike length, plant height, vase life, days to spike initiation, breadth of leaf. The characters no. of floret per spike, no. of spike per plant, plant height showed the moderate estimates of heritability.

The highest estimates of genetic advance as percent of mean was exhibited by days to sprouting (62.58%). Maximum characters showed high to moderate values for genetic advance except length of floret. The Lowest estimates of genetic advance as percent of mean was exhibited by length of floret.

High GCV coupled with high heritability was observed for plant height. Moderate heritability coupled with low genetic advance was observed for breadth of leaf. High heritability coupled with high genetic advance was observed for days to sprouting, vase life, spike length, spike length, no. of spike per plant, no. of floret per spike and plant height. The Length of floret were characterized by moderate heritability with low genetic advance.

Table 4.4. Estimation of genetic parameters for different traits in gladiolus for M_1V_2 generation

Character	Mean	Range	±Sem	GCV(%)	PCV(%)	Heritability(%)	GA(%)
DS	14.72	7.25-15.65	0.48	34.43	34.66	98.6	62.58
PH	96.34	51.35-128.36	7.36	63.90	64.58	97.89	36.34
BOL	3.63	3.08-4.49	0.18	11.73	13.21	78.78	19.03
DSI	66.11	74.47-55.27	1.44	13.76	14.02	96.33	22.01
SL	68.04	27-102	3.35	30.20	30.80	96.16	42.72
RL	39.60	23.25-56	2.06	22.30	23.19	92.41	35.31
NOF	11.57	6.74-15.65	0.53	23.41	24.08	94.50	37.64
LOF	9.85	8.96-10.55	0.51	4.28	7.67	31.21	2.78
BOF	9.08	6.25-11.55	0.28	19.51	19.88	96.34	35.52
VL	6.83	3.53-9.90	0.33	28.31	28.95	95.64	48.57
NOS	1.30	1.25-2.65	0.14	45.86	47.78	92.10	40.40

4.2 Mean performance and interaction (variety × doses)

4.2.1 Days to sprouting

It is evident from the Table 4.5 that various doses and varieties exhibited significant difference for days to sprouting during years of experimentation.

The results indicated early sprouting was in control (7.92days) followed by 20Gy (10.86days) and days to sprouting increases as the doses were increased up to 60 Gy (22.09days).

The effect of interaction between varieties and doses showed earlier sprouting in control (8.38days) followed by 20Gy (11.46days) in M_1V_1 generation. Days to sprouting increases as the doses were increased to 60 Gy (22.68 days). Out of four varieties early sprouting was noticed in variety 'Red Candiman' (15.34days). In M_1V_2 generation, early sprouting was found in control (7.47days) followed by 20Gy (10.25days) and days to sprouting increases as the doses were increased to 60 Gy (21.50days). Out of four varieties early sprouting was noticed in variety 'Red Candiman' (14.18days).

4.2.2 Plant Height (cm)

It is evident from the Table 4.6 that various doses and varieties exhibited significant difference for plant height during years of experimentation.

The result showed plant height was highest in control (116.79cm) followed by 20 Gy (114.47cm) . The plant height was found to be decreased as the doses increased up to 60 Gy (66.81cm).

The effect of interaction between varieties and doses showed maximum plant height in control (116.85cm) in M_1V_1 generation. In treated varieties maximum plant height was found in 20 Gy (114.18cm) followed by 30 Gy (104.93cm) and decreased as the doses were increased to 60 Gy (65cm). Out of four varieties maximum plant height was noticed in variety 'Pasibica Beauty'(108.11cm). In M_1V_2 generation maximum plant height was found in control (116.74cm). In treated varieties maximum plant height was found in 20 Gy (114.77cm) followed by 30 Gy (106.61cm) and decreased as the doses were increased to 60 Gy (68.63cm). Out of four varieties maximum plant height was noticed in variety 'Pasibica Beauty'(108.97cm).

Table 4.5. Effect of different doses of gamma rays on days to sprouting in our gladiolus varieties in M_1V_1 and M_1V_2 generations

Days to sprouting												
M_1V_1						M_1V_2						
Doses	**Red Candiman**	**Pasibica Beauty**	**Summer Sunshine**	**Red Majesty**	**Mean**	**Doses**	**Red Candiman**	**Pasibica Beauty**	**Summer Sunshine**	**Red Majesty**	**Mean**	**Overall mean**
0 Gy	8.13	8.8	8.13	8.46	8.38	**0 Gy**	7.23	7.43	7.5	7.73	7.47	7.92
20 Gy	11.6	11	11.8	11.46	11.46	**20 Gy**	10.16	9.93	10.2	10.73	10.25	10.86
30 Gy	14.4	14.26	14.6	15.13	14.6	**30 Gy**	12.53	12.6	13.63	14.13	13.22	13.91
40 Gy	16.73	17.13	17.26	18.4	17.38	**40 Gy**	15.76	16.5	16.16	17.9	16.58	16.98
50 Gy	19.2	19.93	18.73	20.73	19.65	**50 Gy**	18.86	19.83	17.43	21.06	19.3	19.47
60 Gy	22	22.4	22.73	23.6	22.68	**60 Gy**	20.53	21.76	21.8	21.93	21.50	22.09
Mean	15.34	15.58	15.54	16.3	15.69	**Mean**	14.18	14.67	14.45	15.58	14.72	15.20
CD (5%)	Variety=	1.28	Doses=	1.578	VXD= 0.64	**CD (5%)**	Variety=	1.94	Doses=	2.38	VXD= 0.97	

Table 4.6.Effect of different doses of gamma rays on plant height (cm) in four gladiolus varieties in M_1V_1 and M_1V_2 generations

Plant height (cm)												
M_1V_1						M_1V_2						
Doses	**Red Candiman**	**Pasibica Beauty**	**Summer Sunshine**	**Red Majesty**	**Mean**	**Doses**	**Red Candiman**	**Pasibica Beauty**	**Summer Sunshine**	**Red Majesty**	**Mean**	**Overall mean**
0Gy	111.5	126	97.93	132	116.85	**0Gy**	112.16	127.06	99.43	128.33	116.74	116.79
20Gy	108.6	123.26	97.40	127.46	114.18	**20Gy**	109.83	124.20	98.40	126.66	114.77	114.47
30Gy	99.93	118.33	92.60	108.86	104.93	**30Gy**	100.66	118.66	97.46	109.66	106.61	107.29
40Gy	80	112.13	71.93	102.86	91.73	**40Gy**	80.73	113.06	94.26	95.40	95.86	93.79
50Gy	58.06	84.66	65.33	84.93	73.24	**50Gy**	58.66	85.53	72.93	85.56	75.67	74.25
60Gy	50.46	84.33	56.3	68.93	65	**60Gy**	51.33	85.33	57.2	80.66	68.63	66.81
Mean	84.75	108.11	80.24	104.17	94.32	**Mean**	67.58	108.97	86.61	104.37	96.38	95.56
CD (5%)	Variety	=38.61	Doses=	47.29	VXD= 19.27	**CD (5%)**	Variety	=29.64	Doses=	36.30	VXD=	14.82

4.2.3 Number of leaves per plant

It is evident from the Table 4.7 that various doses and varieties exhibited significant difference for no. of leaves per plant during years of experimentation.

The results showed maximum no. of leaves per plant in 20Gy (11.23) followed by control (10.03). The no. of leaf per plant decreased as the doses increased up to 60 Gy (6.88).

The effect of interaction between varieties and doses was non- significant and the maximum no. of leaves per plant in 20 Gy (10.54) followed by control (9.52) M_1V_1 generation. The no. leaf per plant decreased as the doses were increased to 60 Gy (6.42).. Out of four varieties maximum no. of leaves per plant was noticed in variety 'Pasibica Beauty' (9.99). In M_1V_2 generation maximum no. of leaves per plant was found in 20 Gy (11.92) followed by control (10.55) and decreased as the doses were increased to 60 Gy (7.34). Out of four varieties maximum no. of leaves per plant was noticed in variety 'Pasibica Beauty' (10.55).

4.2.2 Breadth of leaf (cm)

It is evident from the Table 4.8 that various doses and varieties exhibited significant difference for breadth of leaf during years of experimentation.

The results showed maximum breadth of leaf in control (3.86cm) followed by 20Gy (3.56cm). The breadth of leaf decreased as the doses increased up to 60 Gy (2.70cm).

The effect of interaction between varieties and doses showed maximum breadth of leaf in control (3.55cm) followed by 20 Gy (3.23cm) in M_1V_1 geneartion. The breadth of leaf decreased as the doses increased to 60 Gy (2.22cm). Out of four varieties maximum breadth of leaf was noticed in variety 'Red Majesty' (2.98cm). In M_1V_2 generation maximum breadth of leaf was found in control (4.18cm) followed by 20Gy (3.89cm) and decreased as the doses were increased to 60 Gy (3.19cm). Out of four varieties maximum breadth of leaf was noticed in variety 'Red Majesty' (3.98cm).

Table 4.7. Effect of different doses of gamma rays on no. of leaves per plant in four gladiolus varieties in M_1V_1 and M_1V_2 generations

No. of leaves per plant												
M_1V_1						M_1V_2						
Doses	**Red Candiman**	**Pasibica Beauty**	**Summer Sunshine**	**Red Majesty**	**Mean**	**Doses**	**Red Candiman**	**Pasibica Beauty**	**Summer Sunshine**	**Red Majesty**	**Mean**	**Overall mean**
0Gy	7	12.2	8.22	10.66	9.52	**0Gy**	13	10.52	9.82	8.88	10.55	10.03
20Gy	8.8	11.36	12.52	9.5	10.54	**20Gy**	13.25	12.36	11.52	10.55	11.92	11.23
30Gy	7.8	10.56	7.6	8.6	8.64	**30Gy**	8.83	11.56	8.93	9.6	9.73	9.18
40Gy	7.1	9.7	7.1	8	7.97	**40Gy**	8.1	10.7	8.1	9	8.97	8.47
50Gy	6.76	8.63	6.9	6.9	7.3	**50Gy**	7.766	9.66	7.6	7.96	8.25	7.77
60Gy	5.56	7.5	6.33	6.3	6.42	**60Gy**	6.23	8.5	7.33	7.3	7.34	6.88
Mean	7.17	9.99	8.11	8.32	8.40	**Mean**	9.53	10.55	8.88	8.88	9.46	8.93
CD (5%)	Variety	=2.90	Doses	=3.55	VXD=NS	**CD (5%)**	Variety	=1.94	Doses	=2.38	VXD=	NS

Table 4.8. Effect of different doses of gamma rays on breadth of leaf (cm) of gladiolus varieties in M_1V_1 and M_1V_2 generations

Breadth of leaf (cm)												
M_1V_1						M_1V_2						
Doses	**Red Candiman**	**Pasibica Beauty**	**Summer Sunshine**	**Red Majesty**	**Mean**	**Doses**	**Red Candiman**	**Pasibica Beauty**	**Summer Sunshine**	**Red Majesty**	**Mean**	**Overall mean**
OGY	3.27	3.82	3.55	3.58	3.55	**0GY**	4.27	3.47	4.41	4.58	4.18	3.86
20GY	2.99	3.24	3.41	3.3	3.23	**20GY**	3.98	3.43	3.86	4.3	3.89	3.56
30GY	2.98	2.47	2.86	3.02	2.83	**30GY**	3.6	3.36	3.62	4.02	3.65	3.24
40GY	2.55	2.43	2.5	2.9	2.59	**40GY**	3.53	3.22	3.5	3.9	3.53	3.06
50GY	2.28	2.22	2.28	2.57	2.33	**50GY**	3.17	3.19	3.28	3.57	3.30	2.81
60GY	2.08	2.19	2.08	2.52	2.22	**60GY**	3.08	3.08	3.08	3.52	3.19	2.70
Mean	2.69	2.72	2.78	2.98	2.79	**Mean**	3.60	3.29	3.62	3.98	3.62	3.20
CD (5%)	Variety=	0.71	Doses=	0.87	VXD= 0.35	**CD (5%)**	Variety=	0.72	Doses=	0.88	VXD=	0.32

4.2.5 Days to spike initiation

It is evident from the Table 4.9 that various doses and varieties exhibited significant difference for days to spike initiation during years of experimentation.

The results indicated early spike initiation in control (53.43days) followed by 20 Gy (60.67days) and delayed as the doses were increased up to 60 Gy (77.22days).

The effect of interaction between varieties and doses showed early spike initiation in control (54.9days) M_1V_1 generation. In treated varieties early spike initiation in 20 Gy (61.18days) followed by 30 Gy (66.65days) and delayed as the doses were increased to 60 Gy (77.72days). Out of four varieties early spike initiation was noticed in variety 'Pasibica Beauty' (63.07days). In M_1V_2 generation early spike initiation was found in control (51.97days) In treated varieties early spike initiation in 20 Gy (60.17days) followed by 30 Gy (65.65days) . The days to spike initiation delayed as the doses increased to 60 Gy (76.71days). Out of four varieties early spike initiation was noticed in variety 'Pasibica Beauty' (61.67days).

4.2.6 Spike length (cm)

The effect of different doses of gamma ray treatments on spike length was studied and the data were presented in Table 4.10.

The results indicated maximum spike length was in control (88.53cm) followed by 20Gy (85.7cm) and decreased as the doses were increased up to 60 Gy (31.78cm).

The effect of interaction between varieties and doses showed maximum spike length in control (87.27cm) followed by 20Gy (85.2cm) M_1V_1 generation. The spike length was found to be decreased as the doses increased to 60 Gy (31.28cm). Out of four varieties maximum spike length was noticed in variety 'Pasibica Beauty' (72.03cm). In M_1V_2 generation maximum spike length was found in control (89.79cm) followed by 20Gy (86.2cm) and decreased as the doses were increased to 60 Gy (32.28cm). Out of four varieties maximum spike length was noticed in variety 'Pasibica Beauty' (73.03cm).

Table 4.9. Effect of different doses of gamma rays on days to spike initiation of gladiolus varieties in M_1V_1 and M_1V_2 generations

Days to spike initiation												
M_1V_1						M_1V_2						
Doses	**Red Candiman**	**Pasibica Beauty**	**Summer Sunshine**	**Red Majesty**	**Mean**	**Doses**	**Red Candiman**	**Pasibica Beauty**	**Summer Sunshine**	**Red Majesty**	**Mean**	**Overall mean**
0Gy	55.16	51.86	55.6	56.96	54.9	**0Gy**	53.23	49.5	50.16	55	51.97	53.43
20Gy	60.36	55.6	63.56	65.2	61.18	**20Gy**	59.33	54.6	62.56	64.2	60.17	60.67
30Gy	64.83	60	70.63	71.13	66.65	**30Gy**	63.83	59	69.63	70.13	65.65	66.15
40Gy	69	63.16	73.9	74.4	70.11	**40Gy**	68	61.13	72.9	73.4	68.85	69.48
50Gy	71.13	72.36	76.73	77.06	74.32	**50Gy**	70.13	71.36	75.73	76.06	73.32	73.82
60Gy	75.66	75.46	79.96	79.8	77.72	**60Gy**	74.63	74.46	78.96	78.8	76.71	77.22
Mean	66.02	63.07	70.06	70.76	67.48	**Mean**	64.86	61.67	68.32	69.6	66.11	66.8
CD (5%)	Variety	=5.87	Doses	=7.19	VxD= 2.93	**CD (5%)**	Variety	=5.83	Doses	=7.14	VxD=	2.91

Table 4.10. Effect of different doses of gamma rays on spike length (cm) in four gladiolus varieties in M_1V_1 and M_1V_2 generations

Spike length (cm)												
M_1V_1						M_1V_2						
Doses	**Red Candiman**	**Pasibica Beauty**	**Summer Sunshine**	**Red Majesty**	**Mean**	**Doses**	**Red Candiman**	**Pasibica Beauty**	**Summer Sunshine**	**Red Majesty**	**Mean**	**Overall mean**
0Gy	77.43	91.13	80.93	99.6	87.27	**0Gy**	78.4	92.13	88.03	100.6	89.79	88.53
20Gy	74.4	90.8	81.2	94.4	85.2	**20Gy**	75.4	91.8	82.2	95.4	86.2	85.7
30Gy	68.53	81.6	74.46	62.66	71.81	**30Gy**	69.53	82.6	75.46	63.66	72.81	72.31
40Gy	60.2	73.53	71.46	59.33	66.13	**40Gy**	61.2	74.53	72.46	60.33	67.13	66.63
50Gy	55.8	59.13	67	50	57.98	**50Gy**	56.8	60.13	72.13	51	60.01	59
60Gy	29.06	36	34.06	26	31.28	**60Gy**	30.06	37	35.06	27	32.28	31.78
Mean	60.90	72.03	68.18	65.33	66.61	**Mean**	61.9	73.03	70.89	66.33	68.04	67.32
CD (5%)	Variety	=11.91	Doses	=14.59	VXD= 5.95	**CD (5%)**	Variety	=13.49	Doses	=16.52	VXD =	6.74

4.2.7 Rachis length (cm)

The effect of different doses of gamma rays treatment on rachis length was studied and the data were presented in Table 4.11.

The results indicated maximum rachis length in control (43.04cm) followed by 20Gy (35.37cm). The rachis length decreased as the doses were increased up to 60 Gy (21.49cm).

The effect of interaction between varieties and doses showed maximum rachis length in control (31.90cm) followed by 20Gy (26.16cm) M_1V_1 generation and decreased as the doses were increased to 60 Gy (15.77cm). Out of four varieties maximum rachis length was noticed in variety 'Summer Sunshine' (24.14cm). In M_1V_2 generation maximum rachis length was found in control (54.17cm) followed by 20Gy (44.59cm). The rachis length was found to be decreased as the doses were increased to 60 Gy (27.21cm). Out of four varieties maximum rachis length was noticed in variety 'Summer Sunshine' (41.30cm).

4.2.8 Number of floret per spike

The effect of different doses of gamma rays treatment on no. of floret per spike was studied and the data were presented in Table 4.12.

The results indicated maximum no. of floret per spike in control (14.15) followed by 20Gy (13.11) and decreased as the doses were increased up to 60 Gy (6.98).

The effect of interaction between varieties and doses showed maximum no. of floret per spike in control (13.63) followed by 20Gy (12.4) M_1V_1 generation and decreased as the doses were increased to 60 Gy (6.48). Out of four varieties maximum no. of floret per spike was noticed in variety 'Pasibica Beauty' (11.23). In M_1V_2 generation maximum no. of floret per spike was found in control (14.68) followed by 20Gy (13.83). The no. of floret per spike decreased as the doses were increased to 60 Gy (7.48). Out of four varieties no. of floret per spike was noticed maximum sin variety 'Red Majesty' (11.94).

Table 4.11. Effect of different doses of gamma rays on rachis length (cm) of gladiolus varieties in M_1V_1 and M_1V_2 generations .

Rachis length (cm)												
M_1V_1						M_1V_2						
Doses	**Red Candiman**	**Pasibica Beauty**	**Summer Sunshine**	**Red Majesty**	**Mean**	**Doses**	**Red Candiman**	**Pasibica Beauty**	**Summer Sunshine**	**Red Majesty**	**Mean**	**Overall mean**
0GY	30.62	32.94	32.9	31.16	31.90	**0GY**	52.03	55.9	55.83	52.93	54.17	43.04
20GY	24.42	26.92	27.24	26.06	26.16	**20GY**	41.7	45.53	46.7	44.43	44.59	35.37
30GY	22.82	23.9	25.86	23.36	23.98	**30GY**	38.7	40.83	44.1	39.93	40.89	32.43
40GY	21.66	22.02	22.98	21.52	22.04	**40GY**	37.1	37.7	39.3	36.86	37.74	29.89
50GY	18.12	20.92	19.82	18.12	19.24	**50GY**	30.86	35.86	34.03	31.2	32.99	26.11
60GY	16.4	17.1	16.08	13.52	15.77	**60GY**	28.33	29.5	27.83	23.2	27.21	21.49
Mean	22.34	23.96	24.14	22.29	23.18	**Mean**	38.12	40.88	41.3	38.09	39.60	31.39
CD (5%)	Variety=	8.57	Doses=	10.50	VXD=4.28	**CD (5%)**	Variety=	8.31	Doses=	10.18	VXD=	4.52

Table 4.12. Effect of different doses of gamma rays on no. of floret per spike in four gladiolus varieties in M_1V_1 and M_1V_2 generations .

No. of floret per spike												
M_1V_1						M_1V_2						
Doses	**Red Candiman**	**Pasibica Beauty**	**Summer Sunshine**	**Red Majesty**	**Mean**	**Doses**	**Red Candiman**	**Pasibica Beauty**	**Summer Sunshine**	**Red Majesty**	**Mean**	**Overall mean**
0Gy	14.6	14.66	13.66	11.6	13.63	**0Gy**	14.6	15.6	14.13	14.4	14.68	14.15
20Gy	12.86	14.53	11.86	10.33	12.4	**20Gy**	13.73	14.33	13.6	13.66	13.83	13.11
30Gy	11.93	13.93	9.4	10.26	11.38	**30Gy**	12.06	12.93	13.4	12.93	12.83	12.10
40Gy	12.4	9.66	7.66	7.46	9.3	**40Gy**	11	11.06	12.73	12.46	11.81	10.55
50Gy	8	8.13	6.33	9.6	8.01	**50Gy**	8.4	7.8	9.06	9.93	8.8	8.40
60Gy	7.13	6.46	6.53	5.8	6.48	**60Gy**	7.73	6.73	7.2	8.26	7.48	6.98
Mean	11.15	11.23	9.24	9.17	10.20	**Mean**	11.25	11.41	11.68	11.94	11.57	10.88
CD (5%)	Variety	3.45	Dose=	4.23	VXD= 1.42	**CD (5%)**	Variety	2.14	Dose=	2.62	VXD=	0.288

4.2.9 Length of floret (cm)

The effect of different doses of gamma rays treatment on length. of floret was studied and the data were presented in Table 4.13.

The results showed maximum length of floret in control (10.38cm) followed by 20Gy (10.09cm). The length of floret decreased as the doses were increased up to 60 Gy (8.44cm).

The effect of interaction between varieties and doses showed maximum length of floret in control (10.20cm) followed by 20 Gy (9.89cm) M_1V_1 generation and decreased as the doses were increased to 60 Gy (7.83cm). Out of four varieties maximum length of floret was noticed in variety 'Red Candiman' (9.46cm). In M_1V_2 generation maximum length of floret was found in control (10.56cm) followed by 20Gy (10.28cm) and decreased as the doses were increased to 60 Gy (9.05cm). Out of four varieties maximum length of floret was noticed in variety 'Red Majesty' (9.96cm).

4.2.10 Breadth of floret

The effect of different doses of gamma rays treatment on breadth of floret was studied and the data were presented in Table 4.14.

The results indicated maximum breadth of floret in control (11.08cm) followed by 20Gy (10.49cm). The breadth of floret decreased as the doses were increased up to 60 Gy (6.74cm).

The effect of interaction between varieties and doses showed maximum breadth of floret in M_1V_1 generation was found in control (10.84cm) followed by 20 Gy (10.35cm). The breadth of floret decreased as the doses increased to 60 Gy (6.81cm). Out of four varieties maximum breadth of floret was noticed in variety 'Red Majesty' (9.46cm). In M_1V_2 generation maximum breadth of floret was found in control (11.32cm) followed by 20Gy (10.64cm) and decreased as the doses increased to 60 Gy (6.67cm). Out of four varieties maximum breadth of floret was noticed in variety 'Red Candiman' (9.73cm).

Table 4.13. Effect of different doses of gamma rays on length of floret (cm) in four gladiolus varieties in M_1V_1 and M_1V_2 generations

	Length of floret (cm)											
	M1V1						M1V2					
Doses	**Red Candiman**	**Pasibica Beauty**	**Summer Sunshine**	**Red Majesty**	**Mean**	**Doses**	**Red Candiman**	**Pasibica Beauty**	**Summer Sunshine**	**Red Majesty**	**Mean**	**Overall mean**
0Gy	10.09	9.58	9.98	11.16	10.20	**0Gy**	10.46	10.62	10.52	10.67	10.56	10.38
20Gy	9.99	9.56	9.5	10.52	9.89	**20Gy**	10.17	10.33	10.46	10.19	10.28	10.09
30Gy	9.46	9.33	9.32	9.77	9.47	**30Gy**	9.96	10.32	9.8	10.05	10.03	9.75
40Gy	9.42	8.95	9.08	9.29	9.18	**40Gy**	9.06	9.4	9.77	9.96	9.54	9.36
50Gy	9.34	8.8	8.84	8.1	8.77	**50Gy**	9.02	9.34	9.6	9.95	9.47	9.12
60Gy	8.49	8.66	6.94	7.24	7.83	**60Gy**	9	8.82	9.43	8.96	9.05	8.44
Mean	9.46	9.14	8.94	9.34	9.22	**Mean**	9.61	9.80	9.93	9.96	9.82	9.52
CD (5%)	Variety=	2.04	Doses=	2.5	VXD=1.02	**CD (5%)**	Variety=	2.06	Doses=	2.52	VXD=	1.03

Table 4.14. Effect of different doses of gamma rays on breadth of floret (cm) in four gladiolus varieties in M_1V_1 and M_1V_2 generations.

Breadth of floret (cm)												
M_1V_1						$M1V_2$						
Doses	**Red Candiman**	**Pasibica Beauty**	**Summer Sunshine**	**Red Majesty**	**Mean**	**Doses**	**Red Candiman**	**Pasibica Beauty**	**Summer Sunshine**	**Red Majesty**	**Mean**	**Overall mean**
0Gy	10.41	9.9	11.04	12.04	10.84	**0Gy**	11.41	10.9	11.43	11.53	11.32	11.08
20Gy	10.4	9.5	10.55	10.98	10.35	**20Gy**	11.33	10.48	10.53	10.23	10.64	10.49
30Gy	10.34	9.48	9.44	9.96	9.80	**30Gy**	10.63	9.8	9.4	9.66	9.87	9.83
40Gy	9.32	8.96	9.36	8.76	9.10	**40Gy**	9.7	7.7	8.23	8.66	8.57	8.83
50Gy	7.1	8.85	8.06	8.13	8.03	**50Gy**	8.1	6.5	7.5	7.63	7.43	7.73
60Gy	6.24	6.84	7.26	6.93	6.81	**60Gy**	7.24	6.2	6.76	6.5	6.67	6.74
Mean	8.96	8.92	9.28	9.46	9.16	**Mean**	9.73	8.59	8.97	9.03	9.08	9.12
CD (5%)	Variety	=1.61	Dose	=1.97	VXD=0.80	**CD (5%)**	Variety	=1.13	Doses	=1.39	VXD=	0.56

4.2.11 Vase life

The effect of different doses of gamma rays treatment on vase life was studied and the data were presented in Table 4.15.

The results indicated maximum vase life in control (9.29days) followed by 20Gy (7.71days). The vase life decreased as the doses were increased up to 60 Gy (3.54days).

The effect of interaction between varieties and doses showed maximum vase life in control (8.86days) followed by 20Gy (7.25) M_1V_1 generation and decreased as the doses were increased to 60 Gy (3.1days). Out of four varieties maximum vase life was noticed in variety 'Red Candiman' (6.58days). In M_1V_2 generation maximum vase life was found in control (9.72days) followed by 20Gy (8.17days) and decreased as the doses were increased to 60 Gy (3.99days). Out of four varieties maximum vase life was noticed in variety 'Red Majesty' (7.1days).

4.2.12 Number of spike per plant

The effect of different doses of gamma rays treatment on no. of spike per plant was studied and the data were presented in Table 4.16.

The results indicated maximum no. of spike per plant in control (1.71) followed by 20Gy (1.39). The no. of spike per plant decreased as the doses were increased up to 60 Gy (0.61).

The effect of interaction between varieties and doses showed maximum no. of spike per plant in control (1.19) followed by 20Gy (1.09) M_1V_1 generation. The no. of spike per plant decreased as the doses increased to 60 Gy (0.58). Out of four varieties maximum no. of spike per plant was noticed in variety 'Red Candiman' (0.99). In M_1V_2 generation maximum no. of spike per plant was found in control (2.24) followed by 20Gy (1.69) and decreased as the doses were increased to 60 Gy (0.65). Out of four varieties maximum no. of spike per plant was noticed in variety 'Red Majesty' (1.57).

Table 4.15. Effect of different doses of gamma rays on vase life in four gladiolus varieties in M_1V_1 and M_1V_2 generations.

Vase life												
M_1V_1						M_1V_2						
Doses	**Red Candiman**	**Pasibica Beauty**	**Summer Sunshine**	**Red Majesty**	**Mean**	**Doses**	**Red Candiman**	**Pasibica Beauty**	**Summer Sunshine**	**Red Majesty**	**Mean**	**Overall mean**
0 Gy	9.2	8.73	8.93	8.6	8.86	**0 Gy**	9.8	9.33	10	9.76	9.72	9.29
20 Gy	7.73	7.33	6.66	7.26	7.25	**20 Gy**	8.16	7.8	8.5	8.23	8.17	7.71
30 Gy	7	6.6	5.2	6.33	6.28	**30 Gy**	7.16	7	7.83	7.73	7.43	6.85
40 Gy	6.26	5.4	4.2	5.46	5.33	**40 Gy**	6.3	6.03	6.56	6.76	6.41	5.87
50 Gy	5.33	4.26	3.06	4.06	4.18	**50 Gy**	5.8	5.13	4.56	5.66	5.29	4.73
60 Gy	4	3.06	2.26	3.06	3.1	**60 Gy**	4.4	3.63	3.5	4.43	3.99	3.54
Mean	6.58	5.9	5.05	5.8	5.83	**Mean**	6.93	6.48	6.82	7.1	6.83	6.33
CD (5%)	Variety=	1.34	Doses=	1.65	VXD=0.674	**CD(5%)**	Variety=	1.35	Doses=	1.66	VXD=	0.67

Table 4.16. Effect of different doses of gamma rays on no. of spike per plant of gladiolus varieties in M_1V_1 and M_1V_2 generations .

No. of spike per plant												
M_1V_1						M_1V_2						
Doses	**Red Candiman**	**Pasibica Beauty**	**Summer Sunshine**	**Red Majesty**	**Mean**	**Doses**	**Red Candiman**	**Pasibica Beauty**	**Summer Sunshine**	**Red Majesty**	**Mean**	**Overall Men**
OGy	1.26	1.2	1.13	1.2	1.19	**OGy**	1.6	2.4	2.33	2.63	2.24	1.71
20Gy	1.13	1.16	1	1..06	1.09	**20Gy**	1.06	1.73	1.66	2.3	1.69	1.39
30Gy	1.09	1.06	0.75	0.86	0.94	**30Gy**	1	1.36	1.3	1.6	1.31	1.12
40Gy	0.9	0.86	0.66	0.6	0.75	**40Gy**	0.86	1.1	1.1	1.3	1.09	0.92
50Gy	0.86	0.73	0.5	0.66	0.68	**50Gy**	0.7	0.93	0.86	0.93	0.85	0.76
60Gy	0.72	0.6	0.53	0.5	0.58	**60Gy**	0.5	0.76	0.63	0.7	0.65	0.61
Mean	0.99	0.93	0.76	0.76	0.87	**Mean**	0.95	1.38	1.31	1.57	1.30	1.09
CD (5%)	Variety	=0.73	Doses	=0.9	VXD=0.36	**CD (5%)**	Variety	=0.57	Doses	=0.7	VXD=	0.28

4.2.14 Flower colour

In the present investigation chimeras were found in all varieties except Summer Sunshine.

In variety Red Candiman and Pasibica Beauty showed chimeras in 20 Gy, 30 Gy and 40 Gy in both generations i.e M_1V_1 & M_1V_2. In variety, Summer Sunshine no chimera or colour change appeared. In variety, Red Majesty showed chimeras in 20 Gy, 30Gy, 40Gy and 50Gy in both M_1V_1 & M_1V_2 generations.

More number of chimeras seen in Red majesty which is followed by Pasibica Beauty and Red Candiman.

Colour change was observed in the variety Red Candiman in M_1V_1 generation which was validated in M_1V_2 generation. The newly found colour is slightly lighter than control.

The change in flower colour ,chimeras and shape are shown is in plate 2 to 12.

4.3 Genotypic and phenotypic correlation

The genotypic and phenotypic correlation matrix among various traits of gladiolus is presented in table 4.17.

According to phenotypic correlation values no. of spike per plant was significantly positive correlated with spike length (0.536), rachis length (0.591), no. of floret per spike (0.642), breadth of floret (0.524) and vase life (0.635) . The character days to spike initiation was highly significant and negative correlated with spike length (-0.795), rachis length (-0.854), no. of floret per spike (-0.879), length of floret (-0.574), breadth of floret (-0.723),vase life (-0.905), no. of spike per plant (-0.651). Rachis length was observed to have highly significant positive correlated with no. of floret per spike (0.760), length of floret (0.800), breadth of floret (0.898), vase life (0.859) and no. of spike per plant (0.591).

Parent **M_1V_1** **M_1V_2**

Plate 2 : Chimeras in variety 'Red Candiman' of 20 Gy dose.

Parent **M_1V_1** **M_1V_2**

Plate 3 : Chimeras in variety 'Red Candiman' of 30 Gy dose.

Parent **M_1V_1** **M_1V_2**

Plate 4 : Flower colour mutation in variety 'Red Candiman' of 40 Gy dose.

Parent **M_1V_1** **M_1V_2**

Plate 5 : Chimeras in variety 'Pasibica Beauty'of 20 Gy dose.

Parent **M_1V_1** **M_1V_2**

Plate 6 : Chimeras in variety 'Pasibica Beauty'of 30 Gy dose..

Parent **M_1V_1** **M_1V_2**

Plate 7: Flower shape mutation in variety 'Pasibica Beauty'of 40 Gy dose.

Parent **M_1V_1** **M_1V_2**

Plate 8: No chimera in variety 'Summer Sunshine' of 20 Gy dose.

Parent **M_1V_1** **M_1V_2**

Plate 9 : Chimeras in variety 'Red Majesty' of 20 Gy dose.

Parent **M_1V_1** **M_1V_2**

Plate 10 : Flower colour mutation in variety 'Red Majesty' of 30 Gy dose.

Parent **M_1V_1** **M_1V_2**

Plate 11 : Chimeras in variety 'Red Majesty'dose 40 Gy dose.

Parent **M_1V_1** **M_1V_2**

Plate 12 : Chimeras in variety 'Red Majesty' of 50 Gy dose.

Based on Genotypic correlation matrix values we observed that in no. of spike per plant showed a highly significant and positive correlation with plant height (0.710), spike length (0.818), rachis length (0.831), no. of floret per spike (0.937), length of floret (0.803), breadth of floret (0.753), vase life (0.924) where as highly negative correlated with days to spike initiation (-0.925), days to sprouting (-0.949). Days to spike initiation showed a highly significant and positive correlated with days to sprouting (0.908), plant height (0.806). Rachis length was observed to have highly significant positive correlated with plant height (0.777), breadth of leaf (0.634), spike length (0.904) whereas negative correlated with days to sprouting (-0.940), and days to spike initiation (-0.911).

From this matrix it was observed that the genotypic correlation were positively and significant for maximum characters whereas negatively correlated with days to spike initiation and days to sprouting for all character.

4.4 Path Analysis

Path coefficient analysis was done for portioned the genotypic correlation coefficient between a component trait and no. of spike per plant into direct and indirect effect on no. of spike per plant. These direct and indirect effects with no. of spike per plant for genotypic paths were presented in the Table 4.18.

From path analysis table it was observed that character no. of floret per spike had maximum direct Positive effect i.e. 0.915 towards no. of spike per plant correlation. The character breadth of leaf (0.574) exhibited second highest positive direct effect towards no. of spike per plant followed by days to spike initiation (0.307).

Maximum negative direct effect was shown by days to sprouting (-3.368). The character rachis length exhibited a high direct negative effect (-2.245) followed by breadth of floret (-1.650) followed by spike length (-1.186), plant height (-0.393) and vase life (-0.381). Rest all characters exhibited very less positive or negative direct and indirect towards no. of spike per plant. Residual effect of path analysis was 0.52 which indicated that the component characters mostly accounted for variation in no. of spike per plant.

Table 4.17. Genotypic (upper diagonal) and phenotypic (lower diagonal) correlation coefficient between different characters of gladiolus in M_1V_1 generation.

	DS	PH	NOL	BOL	DSI	SL	RL	NOF	LOF	BOF	VL	NOS
DS		-0.713**	-0.253	-0.594*	0.908**	-0.883**	-0.940**	-0.888**	-0.668**	-0.865**	-0.957**	-0.949**
PH	-0.806**		0.435	0.575*	0.806**	0.844**	0.777**	0.767**	0.715**	0.811**	0.789**	0.710**
NOL	-0.271	0.425		-0.125	-0.454	0.337	0.229	0.512	0.165	0.188	0.301	0.447
BOL	-0.68**	0.530	-0.107		-0.410	0.551*	0.634**	0.431	0.708**	0.797**	0.691**	0.527*
DSI	0.933**	-0.713**	-0.497	-0.453		-0.843**	-0.911**	-0.940**	-0.732**	-0.785**	-0.944**	-0.925**
SL	-0.909**	0.735**	0.293	0.467	-0.795**		0.904**	0.764**	0.691**	0.840**	0.811**	0.818**
RL	-0.981**	0.666**	0.220	0.540*	-0.854**	0.845**		0.841**	0.599**	0.811**	0.918**	0.831**
NOF	-0831**	0.627**	0.420	0.337	-0.879**	0.696**	0.760**		0.463	0.691**	0.854**	0.937**
LOF	-0.826**	0.635**	0.206	0.566*	-0.574*	0.867**	0.800**	0.620**		0.810**	0.839**	0.803**
BOF	-0.915**	0.712**	0.190	0.670**	-0.723**	0.906**	0.898**	0.777**	0.709**		0.865**	0.753**
VL	-0.935**	0.713**	0.272	0.597*	-0.905**	0.776**	0.859**	0.924**	0.650**	0.791**		0.924**
NOS	-0.652**	0.485	0.316	0.439	-0.651**	0.536*	0.591*	0.642*	0.439	0.524*	0.635**	

** Significant at P =0.01

* Significant at P = 0.05

Table 4.18. Direct (diagonal) and indirect effect of 12 characters on no. of spikes in gladiolus of M_1V_1 generation.

	DS	PH	NOL	BOL	DSI	SL	RL	NOF	LOF	BOF	VL	rg(NOS)
DS	**-3.368**	0.317	-0.002	-0.390	0.286	-1.078	2.204	-0.813	0.019	1.511	0.365	**-0.949****
PH	2.715	**-0.393**	0.003	0.330	0.017	1.001	-1.745	0.702	-0.016	-1.338	-0.301	**0.710****
NOL	0.913	-0.171	**0.008**	-0.072	-0.153	0.400	-0.516	0.468	-0.003	-0.311	-0.115	**0.447**
BOL	2.290	-0.226	-0.001	**0.574**	-0.139	0.653	-1.423	0.395	-0.016	-1.315	-0.263	**0.527***
DSI	-3.144	0.317	-0.004	-0.260	**0.307**	-1.000	2.047	-0.860	0.172	1.295	0.360	**-0.925****
SL	3.063	-0.332	0.002	0.316	-0.259	**-1.186**	-2.037	0.699	-0.020	-1.496	-0.309	**0.818****
RL	3.306	-0.305	0.001	0.364	-0.280	1.073	**-2.245**	0.769	-0.018	-1.482	-0.350	**0.831****
NOF	2.994	-0.301	0.004	0.247	-0.282	0.906	-1.889	**0.915**	-0.014	-1.282	-0.352	**0.940****
LOF	2.785	-0.281	-0.001	0.406	-0.225	1.028	-1.798	0.567	**-0.023**	-1.337	-0.320	**0.803****
BOF	3.084	-0.319	0.001	0.457	-0.241	-1.075	-2.016	0.711	-0.019	**-1.650**	-0.330	**0.753****
VL	3.226	-0.310	0.002	0.396	-0.290	0.962	-2.062	0.846	-0.019	-1.428	**-0.381**	**0.940****

** Significant at P =0.01 Residual = 0.52

* Significant at P = 0.05

4.5 Mutation frequency, Mutagenic effectiveness and Mutagenic efficiency

Induction of mutation was observed with all the doses of gamma radiation i.e 20Gy, 30Gy, 40Gy, 50Gy and 60Gy. Prominent mutations were observed in all the four varieties evaluated. Highest frequency of mutations were observed under the treatment 40Gy (21.07%), followed by 20Gy(19.60%), 50Gy (19.32%) and 60Gy (19.17%) in M_1V_1 generation. The varieties 'Red Majesty' and 'Pasibica Beauty' were found to have a very high numbers of mutants in the M_1V_1 generation. Highest mutation frequency was recorded in the variety 'Red Majesty' with 40Gy. Highest effectiveness of mutatagens were observed under the treatment 20Gy (9.22%), followed by 30Gy (6.20%), 40Gy (5.26) , 50Gy (3.86%) and 60Gy (3.19%) in M_1V_1 generation. The varieties 'Red Majesty' and 'Pasibica Beauty' were found to have high mutagenic effectiveness in the M_1V_1 generation. Mutagenic efficiency is highest if their value is less so, this condition was observed in 50Gy & 60Gy and in variety 'Summer Sunshine'.

Two mutants identified in the variety 'Red Candiman'(40Gy) and 'Pasibica Beauty' (40Gy) in M_1V_1 generation which were validated in M_1V_2 generation.

Table 4.19. Mutation frequency (%) of different varieties in M_1V_1 generation

Variety	0Gy	20Gy	30Gy	40Gy	50Gy	60Gy	Average
Red Candiman	_	31.37	27.45	15.68	12	8.51	19.00
Pasibica Beauty	_	27.45	13.72	21.57	24.48	_	21.80
Summer Sunshine	_	5.88	7.84	3.92	6.12	15.68	7.88
Red Majesty	_	13.72	25.49	43.13	34.69	33.33	30.07
Average	_	19.60	18.62	21.07	19.32	19.17	19.69

Table 4.20. Mutagenic effectiveness (%) of different varieties in M_1V_1 generation

Variety	0Gy	20Gy	30Gy	40Gy	50Gy	60Gy	Average
Red Candiman	_	15.68	9.15	3.92	2.4	1.41	6.51
Pasibica Beauty	_	13.72	4.57	5.39	4.89	-	7.14
Summer Sunshine	_	2.94	2.61	0.98	1.22	2.61	2.07
Red Majesty	_	4.57	8.49	10.78	6.93	5.55	7.26
Average	_	9.22	6.20	5.26	3.86	3.19	5.7

Table 4.21. Mutagenic efficiency (%) of different varieties in M_1V_1 on the basis of reduction in survivability.

Variety	0Gy	20Gy	30Gy	40Gy	50Gy	60Gy	Average
Red Candiman	0	0	0	0	6.12	1.08	1.44
Pasibica Beauty	0	0	0	0	6.24	0	1.24
Summer Sunshine	0	0	0	0	0.28	0.29	0.11
Red Majesty	0	0	0	0	8.84	0	1.76
Average	0	0	0	0	5.37	0.34	1.14

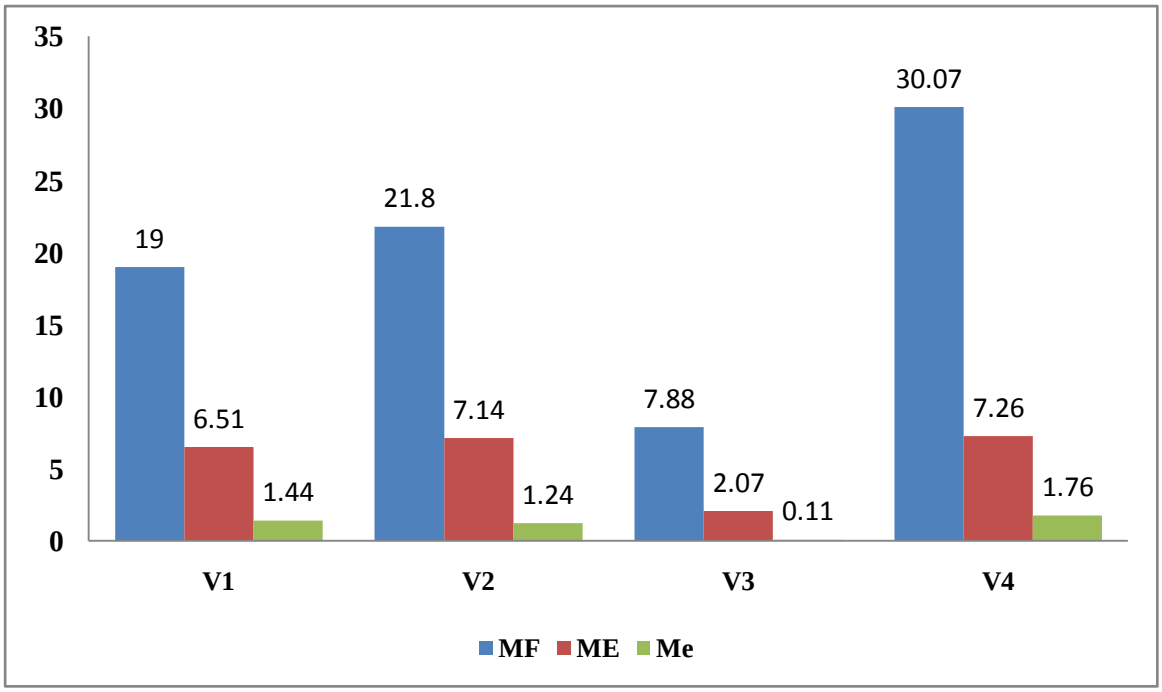

Fig 1: Mutation frequency (MF), mutagenic effectiveness(ME) and mutagenic efficiency(Me) of gamma rays in different varieties.

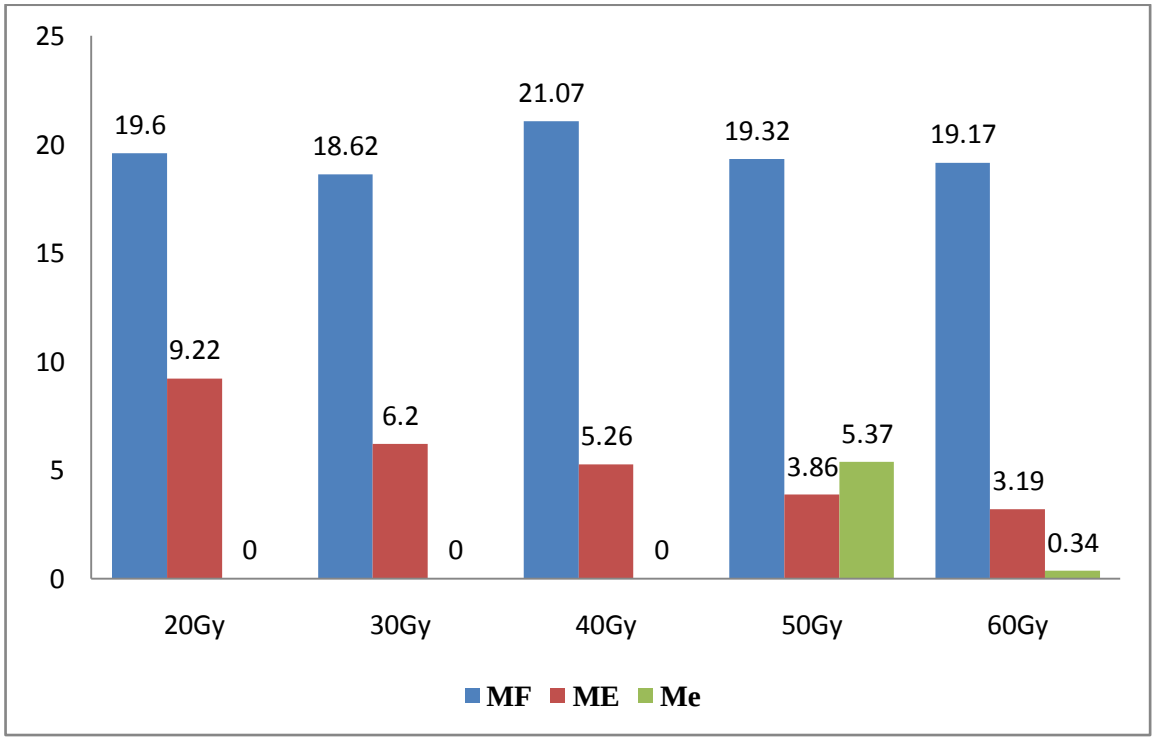

Fig 2: Mutation frequency (MF), mutagenic effectiveness(ME) and mutagenic efficiency(Me) of gamma rays as induced by different doses.

CHAPTER V
DISCUSSION

Gladiolus is an important bulbous flowering plant occupies prime place in ornamental horticulture. It is used in various ways for its attractive spike and long keeping quality, hence, commercially exploited and successfully grown in various parts of India and abroad. The demands of gladiolus is increasing therefore, it needs attention towards genetic improvement. These have mostly been evolved through conventional breeding but few through mutation breeding. Gladiolus is highly heterozygous in its genetic constitution which make it promising test material for inducing physical mutagenesis. The effects of gamma rays on gladiolus have been studied by several workers but very few varieties have been developed through gamma radiations. The creation of novelty is important to meet the demand of present market of this commercially significant flower. Mutation is an effective means for genetic improvement of gladiolus through creation of variability in colour and other desirable traits including disease resistant.

Mutation breeding is solely based on artificial mutation. Among various physical and chemical mutagens gamma rays has been found as effective mutagen for changes in the morphology of the plants. The present study was conducted in the Department of Plant Breeding And Genetics, Assam Agricultural University, Jorhat, Assam to find out the effect of gamma irradiation on growth, flowering and other characters in gladiolus varieties during 2017-2018 and 2018-2019. The results obtained from investigations described well in the proceeding chapter. Attempts have been made to corroborate the experimental findings reported by present investigation with works of various workers in the past and with proper reasoning in this chapter.

5.1 Assessment of genetic variability

The assessment of genetic variability were worked out following analysis of variance and it revealed presence of significant amount of variation among the genotypes. The genetic differences among the genotypes grown in both the generations are reflected in the analysis of variance and estimates the genetic parameters.

Analysis of variance revealed that in the M_1V_1 generation, all the genotypes were found to be significantly different from the control for the characters

studied except no. of leaves per plant. In the M_1V_2 generation, significant differences were observed among all the genotypes for all the characters except no. of leaves per plant.

The analysis of variance by itself is not enough and conclusive to explain all the inherent genotypic variance in the collection. One of the ways in which the variability of these characters assessed is through simple approach of examining the range of variation. Range of variation observed for all the traits in the present study indicating the presence of sufficient amount of variation. The phenotype of the crop is influenced by additive gene effect (heritable), dominance (non-heritable) and epistatis (non-allelic interaction). Hence, it becomes necessary to work out the observed variability into phenotypic coefficients of variability (PCV) and genotypic coefficients of variability (GCV), which ultimately indicate the extent of variability existing for various traits. However, even this does not give a true picture about the extent of inheritance of the character. The effectiveness of selection for any character does not depend on the amount of variability alone but also with estimates of heritability. It is of great interest to the plant breeder to determine how much of the phenotypic variability which is present in particular generation is heritable and the accuracy with which a genotype can be evaluated by its phenotypic expression. Therefore, the heritability (h^2) of a character can be relied upon, as it enables them to decide the extent of selection pressure to be applied under particular environment. The estimation of heritability has a greater role to play in determining the effectiveness of selection of a character provided it is considered in conjunction with the predicted genetic advance as suggested by Panse and Sukhatme (1967).

Comparison among characters as regards to their extent of genetic variability could be best made from the estimates of genotypic and phenotypic coefficients of variation. In the present study, high GCV were observed in spike length followed by no. of spike per plant in M_1V_1 generation and plant height followed by no. of spike per plant in M_1V_2 generation. High PCV was observed for spike length in M_1V_1 generation and plant height followed by no. of spike per plant in M_1V_2 generation. Similarly, Pratap and Rao (2006) also reported higher PCV than GCV for most of the characters studied. Narrow differences between genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were observed for the all 20 characters. Narrow difference between GCV and PCV values indicate the least

influence of environment on these characters. Similar results were obtained by Pragnyasree et al.(2014) and Pratap and Rao (2006) in gladiolus.

Heritability (h^2) and genetic advance (GA) were varied for growth parameters. Higher heritability indicates the effectiveness of selection through phenotypic performance, but it does mean a high genetic gain. Heritability specifies the proportion of total variability that is due to genetic causes and is a good index of transmission of characters from the parents to the offspring (Falconer,1960). Heritability in broad sense worked out from analysis of variance was found to be high in vase life, days to sprouting,, spike length, days to spike initiation, in M_1V_1 generation. In M_1V_2 generation, heritability high in days to sprouting, plant height, days to spike initiation, breadth of leaf, spike length, no. of florets per plant, vase life. Similar results were observed by Pragnyasree *et al*.(2014) and Pratap and Rao (2006) and Balaramand Janakiram (2009) in gladiolus.

The co efficient of variation alone does not offer the full estimation of heritable variation. High heritability coupled with high genetic advance was an indication of additive genetic effects (Panse and Sukhatme, 1978). However, in the current study vase life, days to sprouting, spike length, rachis length and no. of floret per plant was found to exhibit high heritability coupled with high genetic advance in M_1V_1 generation. If high heritability estimated due to non-additive gene action genetic gain will be low; if it is due to additive gene action, expected gain in phenotypic selection will be high (Panse, 1967).

5.2 Mean performance and genetic interaction

5.2.1 Days to sprouting

The results showed that early sprouting at lower doses while sprouting was delayed with higher doses.

The effect of interaction between varieties and doses showed early sprouting in variety ‘Red Candiman’ in M_1V_1 and M_1V_2 generations.

Misra (1977) stated similar condition in which higher doses of gamma radiations adversely affected the sprouting in cv. ‘Oscar’. Pandey and Gaur (1984) recorded that cormels of cv. ‘Scarlet’ irradiated with the low dose generally exhibited slight earliness in sprouting because of increase in O_2 uptake, stimulation of alpha-amylase enzyme prior to sprouting and a rise in sugar content. The higher doses delayed

sprouting, by decreased O_2 uptake and inhibited alpha-amylase activity although it induced a slight rise in sugar content. The enzymes that are set free by irradiations at low doses causes stimulation of sprouting which play pivotal role in plant metabolism as reported by (Srivastava *et al* 2007) in gladiolus.

5.2 2 Plant height

It is evident from the mean data that plant height was gradually decreased with increase in gamma rays dose. The results showed significant effect of gamma rays treatment on plant height. The highest plant height was observed in corms treated with lowest dose of radiation which was at par with control corms. The lowest plant height was found at highest dose.

Out of four varieties maximum plant height was noticed in variety 'Pasibica Beauty' in both generations..

The effect of interaction between varieties and doses showed that the maximum plant height in variety 'Pasibica Beauty' in lowest dose i.e 20 Gy with respect to control and plant height was decreased as the doses were increased in both the generations.

It was observed from present investigation that the plant height was effected significantly due to gamma ray treatments. The plants treated at higher doses resulted in poor growth due to physiological, morphological and cytological disturbance caused by ionizing radiations. Reduction in growth following mutagenic treatments was explained due to auxin destruction and inhibition of auxin synthesis (Gorden 1954). Patil and Dhaduk (2009) recorded the reduction in plant height at higher doses of gamma rays. Tiwari *et al* (2010) irradiated four cultivars of gladiolus using gamma rays and observed significant increase in plant height at lower doses.

5.2.3 Number of leaves per plant

The results showed that the number of leaves per plant was maximum in variety 'Pasibica Beauty' in both M_1V_1 and M_1V_2 generation. As the doses were increased , the no. of leaves per plant decreased in both generation.

The effect of interaction between varieties and doses resulted maximum no. of leaves per plant in variety 'Pasibica Beauty' in both generations. No. of leaves was decreased to as the doses increased in both the generations.

Swaroop and Janakiram (2011) found similar condition in which decrease in no. of leaves as doses increased. Singh and Kumar (2013) showed the best performance with respect of number of leaves per plant at 2.0Kr.

5.2.4 Breadth of leaf

From mean data significant effect of gamma rays treatment was observed on leaf width or breadth of leaf.

The maximum leaf width was found in untreated corms which were at par with treated corm in variety 'Red Majesty' has maximum leaf breadth in both generations.

The results of interaction between varieties and doses indicate that the maximum leaf breadth at control followed by 20Gy. Maximum leaf breadth was observed in the variety Red Majesty in both the generation.

In the present experiment leaves became narrow at higher doses of gamma rays as compare to untreated plants. The reduction in leaf width is due to radiation damage which could be due to physiological, morphological and cytological disturbances caused by ionizing radiations.

Raghava *et al.* (1988) also reported reduction in leaf width in gladiolus varieties after 5, 10 and 15 Krad gamma rays treatment.

5.2.5 Days to spike initiation

The results showed early spike initiation at lower doses while spike initiation were found to be late with increase of doses. The variety 'Pasibica Beauty' showed early spike initiation in both the generations.

The effect of interaction between varieties and doses showed early spike initiation in variety 'Pasibica Beauty' in both year. Days to spike initiation was decreased to as the doses were increased in both the generations .

Sudha D. Patil (2014) showed similar results that the radiation treatments at higher doses caused delayed in spike initiation. Anjana Sisodia, Anil K. Singh (2015) observed that early spike emergence at lower doses of radiation. Findings of Kiran Kumari *et al.* (2018) indicated that gamma radiation treatments had significant detrimental effect on days to spike initiation at higher doses of radiation.

5.2.6 Spike length

The results showed maximum spike length at lower doses while the spike length decreases with higher doses. From mean data and interaction it was observed that 'Pasibica Beauty' showed maximum spike length in both the generations.

Higher doses effect of gamma irradiation was more pronounced which resulted in smaller spike length and reduced flower size. This might be due to reduction in plant growth. The stimulatory effects observed may be due to to acceleration in the release of certain enzymes or the biological compounds from its bound form to scavenge or due to enhanced biosynthesis of ascorbic acid and sulfhydryl compounds (Flaig and Schmid 1966). Tiwari *et al* (2010) irradiated four cultivars of gladiolus using gamma rays and observed significant increase in spike length at lower doses. Sudha Patil, Chawla and Parmeshvari Chaudhary (2017) investigated on "Induction of mutation through mutagens in gladiolus CV. American Beauty" and observed that higher doses adversely affected spike length of gladiolus.

5.2.7 Rachis length

The results showed maximum rachis length at lower doses while rachis length decreases with higher doses of gamma rays.

The effect of interaction between gamma rays doses and varieties indicated that rachis length was adversely affected by higher doses. Rachis length was found to be maximum in 'Summer Sunshine' in both the generations.

Kiran Kumari *et al.* (2018) also reported similar results that rachis length adversely affected at higher doses in gladiolus.

5.2.8 Number of floret per spike

The results showed that the maximum no. of floret per spike at lower doses, while at higher doses the no. of floret per spike decreases.

The effect of interaction between varieties and doses indicated maximum no. of floret per spike in variety 'Pasibica Beauty' and 'Red Majesty' in M_1V_1 and M_1V_2 generation respectively.

The radiation reduced floret number and affected adversely may be because of auxin destruction, irregular auxin synthesis, failure of assimilation, mechanisms or inhibition of mitotic and chromosomal changes or damage with

association of secondary physiological damage. Decrease in floret number with higher doses is mainly due to disturbance in plant physiological processes and decrease in vegetative growth of plants.

Sudha D. Patil (2014) also reported similar results in gamma ray treated in three varieties of gladiolus (*Gladiolus hybrida* L.) namely, American Beauty, Nova Lux and Eurovision and observed that no. of floret decreases at higher doses. These results are in conformity with findings of Sisodia and Singh (2015) who reported that maximum number of florets in control plants and decrease in florets at higher doses of gamma rays in gladiolus.

5.2.9 Length of floret

The results from present investigation showed maximum length of floret at lower doses while length of floret decreases with higher gamma ray doses. The varieties 'Red Candiman' and 'Red Majesty' showed maximum length of floret in M_1V_1 and M_1V_2 generation respectively.

The effect of interaction between varieties and doses showed maximum length in variety 'Red Candiman' and 'Red Majesty' in M_1V_1 and M_1V_2 generation respectively.

Sudha D. Patil (2014) found similar result in which influence of gamma radiation from Co –60 was studied and observed reduced in size of florets. Tiwari *et al.* (2010) carried out a three year mutagenesis programme using physical mutagens (gamma rays) on four cultivars of gladiolus and observed that reduction in floret size when irradiation increases.

5.2.10 Breadth of floret

The results showed maximum breadth of floret at lower doses while length of flower decreases with increase in doses.

The effect of interaction between varieties and doses showed maximum breadth of floret in variety 'Red Majesty' and 'Red Candiman' in M_1V_1 and M_1V_2 generation respectively.

Sudha D. Patil (2014) found similar results in which influence of gamma radiation from Co –60 was studied and observed reduced in size of florets. Tiwari *et al.* (2010) carried out a three year mutagenesis programme using physical mutagens

(gamma rays) on four cultivars of gladiolus and observed that reduction in breadth of floret when irradiation increases.

5.2.11 Vase life

The results showed maximum vase life at lower doses while vase life decreases with increase of doses.

From the interaction effect between varieties and doses vase life were reduced in 'Red Candiman' and 'Red Majesty' with higher gamma ray doses in M_1V_1 and M_1V_2 generations respectively.

Tiwari *et al.* (2010) got similar results as they who noticed that vase life reduced with higher gamma ray doses in gladiolus. Karki (2008) studied the effect of gamma rays on different varieties of gladiolus and reported that the maximum vase life was observed in 1.5 Kr gamma rays treatment and there was decrease in vase life at higher doses *viz.* 2.5 and 3.5 Kr gamma rays. Anu *et al.* (2003) who carried out an experiment on gamma irradiation in different varieties of tuberose and reported that vase life of cut spikes increased at lower doses of gamma irradiation and reduced at higher doses of gamma rays.

5.2.12 Number of spike per plant

The results showed that the more no. of spike per plant at lower doses while no. of spike per plant decreases with increase in doses.

The effect of interaction between gamma rays doses and varieties no. of spike per plant in 'Red Candiman' and 'Red Majesty' in M_1V_1 and M_1V_2 generations respectively. No. of spike per plant was decreased to as the doses were increased in both year.

Tiwari *et al.* (2010) found similar results in gamma rays treated gladiolus. They observed that the number of spike decreases with an increase of gamma ray doses. Sudha Patil *et al.* (2017) investigated on "Induction of mutation through mutagens in gladiolus CV. American Beauty" adversely affected the no. of spike per plant at higher doses.

5.2.13 Flower colour

Chimeras were observed in all varieties except Summer Sunshine.

Colour change was observed in the variety Red Candiman in M_1V_1 generation which was validated in M_1V_2 generation. The newly found colour is slightly lighter than control.

Schum and preil (1998) reported similar results in which 55 % of the records on induced mutation in ornamental plants concerned changes in flower colour and 15 % in flower morphology. According to available literature induction of somatic colour mutations in gamma irradiated plant material may be ascribed to the chromosomal aberrations, break down of phosphate metabolites, accumulation of free amino acids and change in the gene sequence. However, the radioactivity of the variety is dependent upon the genotypes (Datta 2001).

5.3 Character interrelationship

Although, variability estimates provide information on the extent of improvement possible in different characters, they do not throw light on the extent and nature of relationship prevalent between the contributory characters and economically important characters. This could be obtained from simple association analysis that determines the direction and action of different characters. The estimate of genotypic and phenotypic correlations not only display clear picture of the extent of inherent association but based on this analysis, the traits that can be selected in improving the desired variables can be ascertained.

From the correlation studies the interrelationship between the characters was revealed. No. of spike per plant showed a significant positive relationship between other characters such as plant height, breadth of leaf, length of floret, breadth of floret, spike length, rachis length and vase life . No. of spike per plant was showing significant negative correlation with days to spike initiation and days to sprouting indicating earlier spike initiation and sprouting leads to maximum no. of spike per plant. Rachis length was also showing negative correlation with days to spike initiation and days to sprouting indicating earlier spike initiation and sprouting gives to maximum rachis length. Similar observations were made by Pattanik *et al.* (2015) in gladiolus. Similar opinion was also expressed by Pragnyashree *et al.* (2014).

Partioning of total correlation into direct and indirect effects would be worthwhile for an effective selection programme. In path analysis table the direct and indirect effects as well as correlation of different characters with no. of spike per plant were represented. Path coefficient analysis was carried out using genotypic correlation

coefficient for no. of spike per plant. Among all the characters no. of floret per spike (0.91) had maximum direct significant effect towards no. of spike per plant which is followed by breadth of leaf (0.570). The character days to sprouting showed high direct negative effect (-3.360) towards no. of spike per plant which had also negative correlation. The character rachis length showed negative direct effect (-2.240) which was counter balanced by positive indirect effect through breadth of leaf, spike length, no. of floret per spike and resulted in higher correlation with no. of spike per plant. Maximum no. of spike per plant attributing traits such as no. of floret per spike, spike length and breadth of leaf were having high positive direct effect and also exhibited higher positive correlation with no. of spike per plant. So these traits were most important selection criteria for no. of spike per plant. Similar results were observed by Anuradha et al. (2002), Choudhary *et al*. (2011), De and Mishra (1994), Hussain *et al*. (2001), Mishra and Saini (1990) and Sahana (2010) in gladiolus.

5.4 Mutation frequency, Mutagenic effectiveness and Mutagenic efficiency

Mutation frequency and mutagenic effectiveness based on changes in colour or chimeras was highest in variety 'Red Majesty' followed by 'Pasibica Beauty'. Mutation frequency was found to be highest in 40 Gy. Whereas mutagenic effectiveness was found to be highest in 20 Gy.

The mutagenic efficiency seemed to vary depending on the criteria selected for its estimation and the degree of efficiency of various mutagens. The efficiency calculated on the basis of reduction in survivability was generally higher followed by the efficiency based on meiotic aberrations . Mutagenic efficiency could be calculated only in 50Gy and 60Gy in all four varieties means that at higher doses reduction in survivability is more.

The usefulness of a mutagen depends both on its effectiveness and efficiency, efficient mutagenesis with production of maximum desirable changes accompanied by the least possible undesirable changes. Mutagenic effectiveness is a measure of frequency of mutations induced by unit dose of mutagen, where as mutagenic efficiency is indicative of proportion of mutations as against undesirable biological effects such as gross **chromosomal aberrations,** lethality and sterility Konzak *et al*.(1965). A common observation in the present investigation revealed that the degree of effectiveness and efficiency varied between different mutagens and also among the four varieties. Similar differences in mutagenic response have also been reported by many workers Dhanavel *et al*. (2008).In the present investigation, lower or intermediate doses proved to be more effective and efficient. The decrease in effectiveness at higher doses may be attributed to the failure in proportional increase of

mutation frequency with the increase in gamma ray doses. of the mutagens. The higher efficiency at lower and intermediate doses of mutagens as observed in the present study might be due to the fact that the biological damage (reduction in survivability) increased with an increase in dose of gamma rays. Greater effectiveness and efficiency of lower or intermediate treatments of chemical mutagens alone or in combination with gamma rays was reported by Dhanavel *et al*. (2008) Lower or intermediate doses cause relatively less damage in gladiolus to express the induced mutations successfully.

CHAPTER VI

SUMMARY AND CONCLUSION

The present investigation was carried out during 2017-2019 at Instructional Cum Research Farm of Assam Agricultural University, Jorhat to study the genetic variability, the association and causal relationship among the traits and to asses mutation frequency, mutagnic effectiveness and mutagenic efficiency of gamma rays in four gladiolus varieties. The experiment was laid out in a FRBD with three replications Observations were recorded for 12 characters and reduction survivability of plant to determine mutagenic efficiency of gamma rays. Mutants were identified on the basis of formation of chimeras.

The important findings of the investigation are summarized below:

1. Large extent of variation was observed among the genotypes in both M_1V_1 and M_1V_2 generation.
2. In both generations all genotypes showed significant differences for all the characters except number of leaves per plant.
3. In M_1V_1 generation, high GCV and PCV were recorded in spike length followed by no. of spike per plant and plant height (cm) followed by no. of spike per plant in M_1V_2 generation.
4. In present investigation high heritability was observed for days to sprouting followed by vase life, days to spike initiation, spike length (cm) and no. of spike per plant in M_1V_1.
5. In M_1V_2 generation high heritablity was found to be in days to sprouting followed by plant height (cm) and vase life. High heritability and high genetic advance were observed for vase life followed by spike length (cm) and spike length (cm) in M_1V_1 generation and for days to sprouting followed by vase life and spike length (cm) in M_1V_2 generation.
6. From the interaction table we observed the following:
   - Early sprouting, was recorded maximum in control followed by 20 Gy in variety Red Candiman in both M_1V_1 and M_1V_2 generation.
   - Plant height (cm), days to spike initiation, no. of leaves per plant and spike length (cm) was recorded maximum in control whereas minimum was

recorded at higher dose of 60 Gy in variety Pasibica Beauty in both generation.

- Length of floret (cm), breadth of floret (cm), no. of spike per plant and vase life was recorded maximum in control where as minimum was recorded at higher dose of 60 Gy in variety Red Candiman and Red Majesty.
- Breadth of leaf was recorded maximum at control whereas minimum at 60 Gy in variety Red Majesty. Rachis length was recorded maximum in control followed by 20 Gy in variety Summer Sunshine.
- Number of floret per spike was recorded maximum in control followed by 20 Gy in variety Pasibica Beauty and Red Majesty.
- Number of leaf per plant was found to be higher in treated corms i.e. 20 Gy where as minimum was recorded at higher dose of 60 Gy in variety Pasibica Beauty.

In both generations, chimeras was observed in 20 Gy, 30 Gy and 40 Gy doses and more no. of chimeras were observed in the variety'Red Majesty'.

7. No. of spike per plant showed a significant positive genotypic correlation between other characters such as plant height, no. of leaves per plant, breadth of leaf, length of floret, breadth of flower, spike length, rachis length and vase life in M_1V_1 generation . The character no. of spike per plant was showing significant negative correlation with days to spike initiation and days to sprouting indicating earlier spike initiation and sprouting leads to maximum no. of spike per plant. Rachis length was also showing negative correlation with days to spike initiation and days to sprouting indicating early spike initiation and early sprouting gives to maximum rachis length.
8. From path analysis, it is evident that among all characters no. floret per spike had maximum direct significant effect towards no. of spike per plant which is followed by breadth of leaf. The character days to sprouting showed high direct negative effect towards no. of spike per plant which had also negative correlation. Character rachis length showed negative direct effect which was counter balanced by higher positive indirect effect through breadth of leaf, spike length, no. of floret per spike and resulted in high correlation with no. of spike per plant. Maximum no. of spike per plant attributing traits such as no. of floret were having high positive direct effect and also exhibited higher positive correlation with no. of spike per plant. So, no. of floret had most important selection criteria for no. of spike per plant.

9. Highest mutation frequency was recorded in the variety Red Majesty with 40Gy. Highest mutagenic effectiveness were observed in variety Red Majesty and Pasibica Beauty with 20 Gy. Mutagenic efficiency high in 50Gy & 60Gy and in variety Summer Sunshine.
   - Two mutants were validated in M_1V_2 generation in the variety 'Red Candiman' and 'Pasibica Beauty' in 40 Gy.
   - The mutation induction frequency of gamma rays in a particular dose varies from genotype to genotype.

From the present investigation different chimera and colour changes were observed. The micromutants like chimeras could arise due to chromosomal aberration induced by gamma rays. Macromutants observed in changes in flower colour and shape in flower probably arise as a result of gene mutations. The mutants found in the present investigation should be validated in subsequent generation for developing as variety.

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APPENDIX – I

Meteorological data during the period of experimentation

Period	Temp. (°C)		RH (%)		Total BSSH (hrs.)	Total RF (mm)
	Max.	Min.	Morn.	Even.		
2017						
October	31.1	23	96	77	160.5	192.8
November	28.4	16.2	95	68	222.5	14.7
December	25.8	12.7	99	69	168.2	0.0
2018						
January	23.9	11.0	98	69	144.6	2.7
February	24.5	13.2	97	67	94.9	29.1
March	27.3	16	95	64	124.1	76
October	29.6	20.5	96.8	69.3	165.9	17.4
November	26.7	14.9	97.6	65.9	183.5	32.4
December	24.9	10.9	97.5	63.0	203.1	29.6
2019						
January	24.6	9.2	95.0	61.1	215.7	10.7
February	24.8	12.4	94.3	63.5	126.9	36.0
March	27.0	15.7	91.2	61.3	120.0	77.2